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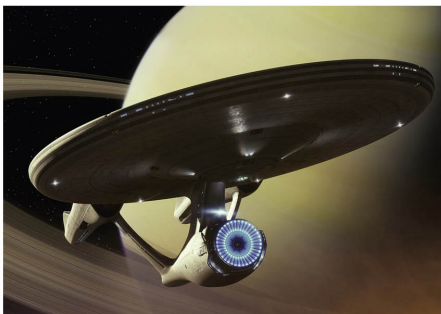
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Moon Madness

ARTICLE BY E.TELLE SHAY

The 1970s and early '80s gave birth to some of science fiction cinema's most enduring classics, but for British commercials director Duncan Jones, it was not the era's groundbreaking visual effects that distinguished the best of them, but rather stories and characters of substance, and a willingness to explore the more serious underpinnings of the genre. An admitted sci-fi geek, Jones sought inspiration in such films as *Silent Running*, *Alien* and *Outland* as he segued into features directing with *Moon* – his *Outland* as he segued into features directing with *Moon* — his ambitious debut project, made on a shoestring budget of just \$5 million, and featuring a tour-de-force performance by actor Sam Rockwell.

In *Moon*, set in the near future, astronaut Sam Bell is approaching the end of a lonely three-year stint on Sarang, an isolated moon base established by Lunar Industries to mine Helium-3, now earth's principal source of renewable energy. As the solitary human in charge of the mining operation, Sam is just weeks away from his scheduled return to earth when he suddenly begins experiencing hallucinations. After a near-fatal accident in his moon rover that lands him in sick bay, attended by the base's robotic computer Gerty, Sam's world turns upside down when he awakens to confront his clone — a slightly younger and considerably healthier version of himself who not only looks and talks just like him, but also shares his memories.

Essentially a one-man character piece, *Moon* was conceived as a star vehicle for Sam Rockwell by Jones, who wrote the initial treatment and collaborated with Nathan Parker on the screenplay. "Moon came about because I was ready to do my first feature," Jones recalled. "I had met up with Sam to discuss another script. That script didn't work out; but at the meeting we got on very well, and discovered that we both loved science fiction. I told Sam I really wanted him to be in my first feature film, and that I would write something for him."

As the story began to coalesce in Duncan Jones' mind, he and producer Stuart Fenegan drew up a

image



For his feature directorial debut, writer/director Duncan Jones conceived *Moon* – a near-future drama set entirely on the moon – as a one-man character piece for actor Sam Rockwell, who portrays astronaut Sam Bell, the only human manning the Sarang energy mining base on the far side of the moon. Jones shot the film on a bare-bones budget in just 33 days, maximizing production values on an ambitious slate of effects through careful allocation of resources and a helping hand from a miniatures team led by model unit supervisor Bill Pearson, and a Cinesite visual effects team under the supervision of Simon Stanley-Clamp.



Following an accident in his rover, Sam is rescued by a clone of himself who suddenly appears on the scene. Interiors were shot at Shepperton Studios on a mining base set built as a fully-enclosed 360-degree environment. Jones and concept artist Gavin Rothery worked closely with production designer Tony Noble to design the

bullet list of considerations to be addressed in order for the nascent project to have any hope of getting made. Topping the list was the need to attract and hook Rockwell by creating a story idea that offered him some challenges as an actor. Other

interiors with a retro aesthetic inspired by classic science fiction cinema from the early 1980s. Rothery also designed the base's non-anthropomorphic computer robot, Gerty, realized through a combination of live-action prop built by Pearson and his team, and a CG replica created by Cinesite.

considerations had more to do with the clear

budgetary constraints. "We knew upfront what kind of budget we were facing," observed Jones, "so it was a slightly backwards process in that we had the budget first, and then we had to make a project to fit it. The idea of using clones came about both because of the story I was interested in writing, and also because we could get away with a lot of over-the-shoulder shooting and some fairly simple split-screens, and then dress that up with a few money shots requiring motion control. So it was an effect that could run throughout the film that was visually quite interesting, but which wouldn't necessarily cost that much to create."

Fortunately, Jones' work with commercials had given him ample exposure to visual effects. Comfortable with the technology, he favored an approach that combined traditional models and miniatures with contemporary postproduction techniques. With that in mind for *Moon*, Jones enlisted veteran modelmaker Bill Pearson to build miniatures of the moon base and its vehicles for all of the lunar exteriors, and then called upon Cinesite, under visual effects supervisor Simon Stanley-Clamp, to provide digital support. "Shooting this mixture of live-action and CG," said Jones, "meant that we could get the most bang for the buck and create something that had a lot of texture. We could give the film a real sense of epic scale, but at the same time be able to capture as much in-camera as possible. Then Cinesite would be there to back us up, and bring the most out of what we had been able to shoot."

With less than two months of preproduction, and just 33 days allotted for principal photography at Shepperton Studios, Jones sought the help of longtime friend and collaborator, conceptual artist Gavin Rothery. "Gavin has a fantastic eye," commented Jones, "so he was pretty much my other half in terms of getting this film made on the visual side. He did all of the initial designs for the interior layout of the mining base, what the rooms would look like, and worked hand in hand with our production designer Tony Noble. He also worked with me on the initial concepts for the moon vehicles and for Gerty, which were then interpreted by Bill Pearson and his team."

Jones and Rothery sought a look for the mining station's cold white interiors that was spare and utilitarian — a retro aesthetic influenced by the work of such classic futurists as Syd Mead and Ron Cobb, and by the films Jones had grown up loving. "We had an infirmary in the base that was our little homage to a Syd-Mead-designed room," revealed Jones, "and we sort of took different parts of Sarang and designed them based on films or concept artists that we really respected. Some of our pressure doors, for example, are like ones we recalled loving from *Outland*."

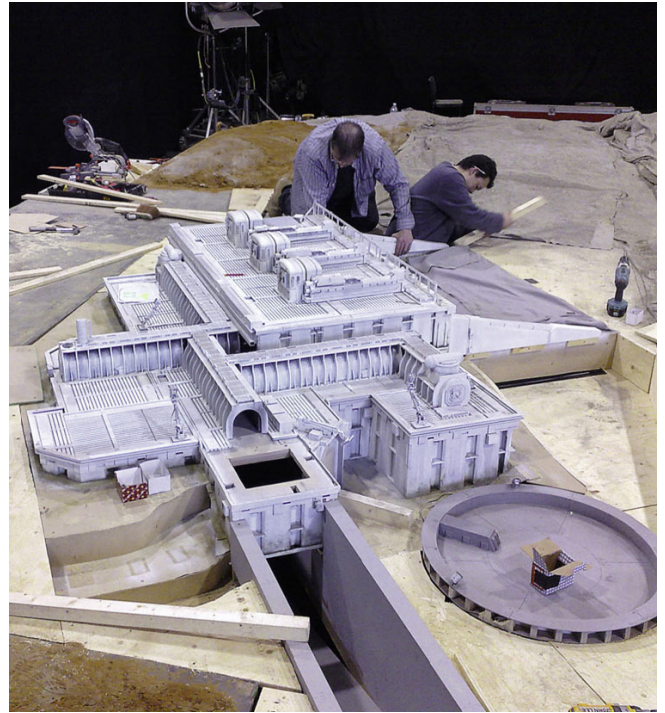
At Shepperton, on the same soundstage where Ridley Scott had filmed *Alien* almost 30 years earlier, Noble and his crew built the Sarang interior as a fully enclosed 360-degree environment, ceilings and all. "When we started designing the sets," related Jones, "there were walls which theoretically were able to fly. But the amount of time it would have taken to do that was just too prohibitive. So we ended up making a stylistic decision that we would treat the set more like a location, and just

assume that sometimes we weren't going to be able to get the camera exactly where we wanted it. Once in a while we would break with that style and cut or move a wall, if it was really important for a shot; but I think having a fully enclosed environment was good for Sam, because it gave him much more of a sense of isolation."

Moon opens with Sam Bell tending to his routine chores inside the mining station, assisted by Gerty, a nonhumanoid robot vaguely reminiscent of HAL 9000 from *2001: A Space Odyssey*. Voiced with ominous calm by Kevin Spacey, Gerty travels about the base on a runner attached to a track in the ceiling, his roving camera eye allowing him to see, and his mainframe monitor flashing happy or sad faces as a sort of simplistic emotional barometer. Detached large and small robotic arms move about the base in similar fashion, performing various labors ranging from heavy lifting to intricate tasks such as cutting Sam's hair.

Static closeups of Gerty were captured on the set with a full-size prop designed by Rothery and built by Bill Pearson and Steve Howarth, foreman of the five-man modelmaking team. "Early on," observed Jones, "we were thinking maybe we could actually mount Gerty properly and physically to the set, and have a rigger on top of the set moving him around; but it quickly became obvious that was not going to be feasible because of the amount of structural work we'd have to do." Instead, Pearson and Howarth built a simple, non-mechanized robot body, affixed to a support rig on wheels that could be framed out of shots, if needed. Large and small arm units were built as separate posable props that could be articulated on set with rods or wires.

Given the limitations of the practical props, wide shots of the robot and its components traversing the moon base on the ceiling tracks were achieved with a CG Gerty built by Cinesite to match the real props, and composited into the live-action photography as needed. To match the subtle differences between the day and night lighting scenarios on the live-action set, Cinesite surveyed the set with lidar scans and did two days of extensive HDRI photography on the interiors and for specific shots. The CG Gerty and its



Modelshop foreman Steve Howarth and modelmaker Peter Lee assemble a 1/12-scale miniature of the Sarang mining installation, based on loose concept art by Gavin Rothery. For the sake of time and cost efficiency, modelmakers used existing materials to construct the base, including a supply of old styrene computer boxes cut up to provide exterior detailing, and assorted bits and pieces left over from past projects.



The miniature moon base stands ready for shooting on a small stage at Shepperton. Modelmakers also built a section of lunar terrain and an assortment of vehicles for

components ended up being used in some 35 shots, mixed and matched in with the practical props to sell the idea of the robot moving freely about the base. “There was a lot of heartache as far as deciding which bits of our CG Gerty we’d be able to use in which scene, and where we’d be able to move him,” Jones admitted. “I was always pushing for more of the CG Gerty; but sometimes I’d have to just let him be static, because that’s all we could afford.”

exterior shots, filmed during an eight-day miniature shoot that followed completion of principal photography.

Later in the story, Sam awakens in sick bay after an accident to discover a carbon copy of himself inside the base. From that moment on, Rockwell would play dual versions of the same character — the rapidly deteriorating Sam 1, and the slightly younger, more energetic Sam 2. For inspiration in planning shots of the twin Sams together in scenes, Jones studied two films noted for their twinning effects — David Cronenberg’s *Dead Ringers* and Spike Jonze’s *Adaptation*. “There’s a huge ‘making of’ section on the Criterion edition of the *Dead Ringers* DVD that was incredibly useful,” Jones noted. “It was kind of our initial stop as far as thinking through how we were going to approach the work, and we watched it many times. Then I had the good fortune to talk to Spike Jonze briefly before we started shooting, and he gave me some sage advice. He told me that when you’re working through scenes, you need to choose which character really leads the scene, and shoot that one first.”



Modelmaker John Lee dusts a section of miniature moonscape for shots of Sam traversing the lunar landscape in his moon rover. To simulate the fine lunar dust, Pearson concocted a mixture of powder paints and kitty litter, applied as a topcoat over the miniature terrain built on three-foot-high platforms. Working from detailed designs by Gavin Rothery, modelmakers built the three rovers featured in the film in 1/12-scale, plus a 1/6-scale chassis with interchangeable cabs for closeups. Since none of the vehicles was equipped with radio control, tungsten wires were used to attach the rovers to rolling drums, allowing them to be maneuvered manually on the set.

Cinesite handled the twinning effect, which ranged from classic split-screens — many with nodal-point pans and tilts, and most with moving splits — to inventive motion control shots with complex camera moves and physical interaction between the two Sams. Cinesite artists relied on rotoscoping and difference matting techniques for the character crossovers, since greenscreens were not an option in the enclosed set, where bright-white interiors would have reflected.

The on-set motion control was achieved in a single week’s worth of shooting, using a fast-moving, portable rig called SPROG that cinematographer Gary Shaw managed to secure from The Visual Effects Company. “Out of all the clone shots,” said Stanley-Clamp, “there are probably eight in the film that are motion control, where we had to do repeat passes with Sam 1, Sam 2 and a clean plate. Mostly, those shots worked due to careful planning and a great performance by Sam Rockwell. With an hour’s makeup change between takes, Sam would study his performance, memorize it just looking back at it on a video iPod, and learn the beats. Of course, we used a video overlay to check the lineup and things — but Sam always knew where he should be standing so he wouldn’t walk into himself.”

Though used judiciously, the occasional complex gags helped keep the visuals fresh. “Over the course of the film,” noted Duncan Jones, “we tried to work it out so that every once in a while, before the audience started to get too jaded or bored with the trick, we would throw in another little twist with another nice little effect. Because of our budget, we had to constrain it to just a few of those moments; but I think we balanced it so that those moments happen throughout the film.”

Though much of *Moon*’s story unfolds inside the claustrophobic confines of the mining base, Duncan Jones knew that to keep the story alive, it would also have to move outside, where the challenges of creating a convincing lunar environment were considerable, given the film’s limited resources. Seeking a slightly stylized, yet still realistic, visual signature for the exteriors — which included aerial views of the moon and earth, shots of the mining base and lunar landscape, and action shots of the rovers and rock-churning harvester machines used in the mining operation — Jones turned for inspiration to the book *Full Moon*, by Michael Light. “The book is largely cleaned-up and beautifully presented 70mm photography from the Apollo moon missions,” Jones commented, “and it was our visual bible. Everyone used it as a guide — Bill Pearson’s team had it, Cinesite had it, and all of the art department had it. The photos look almost monochromatic; but once in a while you see a lunar rover on the surface, which provides a splash of bright color, and you realize that it’s not black-and-white photography — it’s actually color photography. It’s just that there’s no color up there. So that’s something that we tried to emulate both in the live-action photography and in the color grade afterwards. Obviously, being in a studio that was fairly compact, we weren’t able to get our key lights quite as hard and as far back as needed to get the crisp shadows we wanted, but we did what we could with contrast, and then added little flourishes to give it a look that was similar to what we saw in the *Full Moon* photography.”

Having decided to capture as much as possible of *Moon*’s exteriors through traditional models, Jones called upon Bill Pearson and his team to build the lunar landscape, mining station and vehicles in miniature. It was just the sort of challenge that Pearson — an old-school veteran with 30 years of experience working in the trenches at Shepperton — excelled at. “This was basically garage filmmaking,” Pearson proclaimed. “There’s no other way to describe it. We had to pull everything out of a hat. Fortunately, for most of my crew, God is Derek Meddings. So we were always asking, ‘How would Derek have done it?’ That was our starting point.”

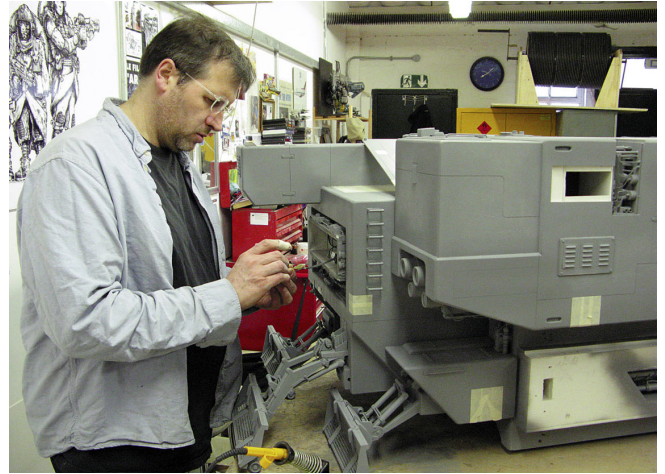


A rover approaches one of Sarang’s automated harvesters, a huge tractor-like device used to gather lunar soil and rock samples for a Helium-3 extraction process essential to the mining operation. The sequence was filmed on the miniature stage with the 1/12-scale models of the rover and harvester. For all of the traveling rover shots, digital artists at Cinesite composited in starfield backgrounds and digitally extended the views in all directions, making full use of a massive lunar panorama, created by matte painter Roger Gibbon, that was continually repositioned, repainted and plugged into shots as needed.

Much to Pearson's delight, Jones and Gavin Rothery had approached him armed with much more than just enthusiasm. "They were very well prepared," Pearson recalled. "They had put together a lot of animatics for the exterior shots, and as soon as it was agreed that it was going to be models, I was privy to all that. Also, the difference between me and others is that all my guys tend to be design modelmakers, who don't actually have to wait around for drawings. Gavin had designed the rovers; so we had specific plans for those vehicles. But everything else — the harvesters, the moon base, a couple of spaceships that we see at the end — those were just sketches, and we had some freedom in the designs. We are all creative people, and if we can put something into the project of ourselves, that's great. Moon gave us a chance to do that, and it really was the only way to do this show. By designing the stuff as well as building it, we could cut corners and we could cut time."

Pearson was taken aback when he learned that the production planned to use a small workshop, rather than a stage, to shoot the miniatures. "I said: 'You've got to be joking!' And they said, 'Sorry!' So I went to the studio management and said, 'We need a stage.' They gave us a small one, and then I worked backwards with Peter Talbot, our model DP, to come up with what we could comfortably put on that stage. With a 40-by-25-foot moonscape, we figured we'd have to go to 1/12-scale for the moon base and vehicles in order to get decent shots — which is really tiny! So, for closeups of the rovers, I thought, 'We'll just have to do some G.I. Joe-size versions in 1/6 scale.'"

Working from Gavin Rothery's designs, the modelmakers built three distinct rovers in the smaller scale, and just the rover chassis in the larger scale, with three interchangeable cabs that could be plugged into it. A single harvester was built; but with more latitude in the design, Pearson used time-honored kit-bashing techniques. "I bought about eight German tractor toys and took the chassis off of them to use," Pearson related. "I also had a massive box of bits and pieces left over from *Casino Royale*, and that's what went into the two shovel scoop areas. Then, because the treads on the German toys weren't wide enough, I went down to the local car shop and bought a load of rubber floor mats, cut those up and superglued them together to make the moving treads."



Steve Howarth adds detail to the harvester model. Given considerable latitude in the design of the vehicle, modelmakers were able to cut corners on construction by using old-school kit-bashing techniques and chassis pieces cannibalized from toy construction vehicles.



Bill Pearson switches on a rear light on the harvester in preparation for shooting on the miniature stage. In post, Cinesite tracked in additional practical vehicle lighting, such as rotational beacons on the arms of the harvester, and added layers of churning rocks, dirt and dust, generated via particle simulation and composited into shots of the harvester in operation.

Pearson and his crew also had some latitude in constructing the 15-foot-long mining base miniature, whose architectural footprint included a control tower with antenna array, a conical-shaped rocket — ostensibly for shuttling astronauts back and forth to earth — and a garage for housing the rovers. Once again, the crew relied on clever low-budget solutions to cobble together the model. “Anything I had lying around on my shelves or in the bin suddenly got grabbed and stuck on that model,” Pearson recalled. “We used a load of old styrene computer storage boxes that I’d bought for the movie *Red Dwarf* as external detailing, and even used the interior of those boxes for the walls of the rover bay. The ground pallets that you see in the bay — those were actually filter units from aquariums. But I was stuck on what to do for the roof of the bay, until one day, as I was coming back from washing my hands outside my workshop, I noticed all these plastic toilet paper dispensers that were being thrown out. So I told my guys to put some gloves on and go get them. We cleaned up about a half dozen of them, put them through the circular saw, and that’s what ended up as the roof.”

For the lunar terrain surrounding the mining base, modelmakers used three-foot-high platforms covered in a layer of sand and then stapled gray felt material on top of that to better approximate the colors and textures of the real lunar landscape. Pearson concocted a novel mixture for the final powdery topcoat — kitty litter mixed with black and white powder paints. “We knew the rovers would be moving across the surface,” said Pearson, “and we wanted them to leave tracks and kick up dust. But then Duncan came in and said: ‘Sorry, guys. It’s one-sixth gravity, and we don’t want dust. We’re going to put a digital dust effect in later.’ So I just ordered a lot of killer sprays; and, in between takes on the stage, we’d wet down the moonscape to stop the dust from rising.”

Both Pearson and Stanley-Clamp joined Jones and Talbot for the eight-day miniature shoot, conducted on the small stage after principal photography had wrapped. With some 20 shots slated for completion each day, the pressures were intense. Since none of the lunar vehicles was radio controlled, shots of the rovers traversing the lunar landscape, and shots of the bulky harvester in action had to be accomplished with wires. “We’ve got a term for that,” quipped Pearson. “We call it ‘handimatic.’ Everything in this movie had to be pushed and pulled.” It was an approach that clearly had its drawbacks, particularly when it came to wrangling the heavy harvester. “There was one scene where it had to move 90 degrees, and hit its mark. We were dragging it with tungsten wires towards camera, and had to spin it, basically. I was on the main steering wire, trying to pull the thing around, and I’d underestimated how heavy it was. I pulled it around to 90 degrees, and hit the mark, and everyone said, ‘Terrific!’ Then I looked down at my hand, and I had this very deep cut from the wire, and there was blood gushing everywhere.”



On the miniature set, filmmakers prepare for a scene in which Sam 2 visits the site of an earlier crash between Sam 1’s rover and the harvester. With practical lighting on the miniature set limited to standard LEDs, Cinesite enhanced most of the rover and harvester shots in postproduction, adding lens flares, flickering lights and other lighting flourishes to keep the miniatures from looking too static. For a visual signature in all the lunar exteriors, effects crews sought to emulate dramatic, high-contrast NASA photography from the Apollo moon missions.

For shots of the harvester scooping up lunar soil, Cinesite added some 16 layers of lighting effects, dust and rocks, meticulously tracked into the plate photography. “There were various different sizes of dust,” said Simon Stanley-Clamp, “a couple of layers of boulders scooped up by the arms of the harvester at the front, dust that flies up and over the arms, bigger rocks that are spat out the back, and then lights and lens flares. In some cases we tracked in additional panels of the harvester and painted up detail, just to give it scale — perhaps a panel with smaller bolts or nuts — so that if you got particularly close, you would think it was bigger than it really was. Everything required pretty extensive tracking, because even though the harvester wasn’t moving very fast, the arms bounced around.”

Less digital finessing was required for the rovers, though Cinesite artists added lights and dirt to the vehicles, tracked in dust and rocks coming off the wheels, and incorporated various 2D gags to keep things moving. Insert shots of Sam in the rover looking out at the moonscape were captured separately during a week-long greenscreen shoot, with Rockwell in a rover cab mounted on a motion base. Cinesite then comped in the moonscapes seen through the window.

Cinesite also digitally extended all of the lunar landscapes — visible in the traveling rover shots and through the windows of the mining base — tracking in starfields and extending the vistas in all directions. “The miniature lunar landscape was probably half the size of a tennis court, which was as big as they could afford,” noted Stanley-Clamp, “but we knew it was never going to be big enough. So every time a rover is in a shot, that landscape had to be extended.” Cinesite matte painter Roger Gibbon created a massive panorama for the shots, using the NASA photography as reference. Artists then customized it for each of the extended miniature shots, plugging in segments as needed, repositioning and repainting them to reflect the correct geography, ensuring continuity in the lunar topography and in the starfields. Gibbon also created digital matte paintings for views of the moon and earth as seen from space, featured in the movie’s opening. Digital artists wrapped the imagery onto simple geometry to give it a spherical look, and enhanced it with a slight move in post.

The Cinesite team added other digital enhancements. “Pretty much every exterior shot had a post lens flare,” said Stanley-Clamp. “It was something Duncan loved. Even when we were shooting, if something caught the camera and shone into the lens he kept it, because it was a look he really wanted. Optical accidents, I’d call them. We also shot some practical elements — rotating



Cinesite employed a range of split-screen techniques to sell the two Sams — both played by Sam Rockwell — interacting in scenes. For a shot of Sam 2 feeling the forehead of Sam 1, three passes were done during a week-long motion control shoot. In the hero pass, Rockwell as the ill Sam 1 performed to a stand-in serving as Sam 2, with a C-stand used to record the position of the double’s left shoulder. In the second pass, Rockwell performed as Sam 2, aligning his shoulder with the marker and using his body to occlude that of the double. A third pass allowed for the removal of extra lighting, cameras and floor markers, and the shadow cast by the C-stand and opposing action. In post, Cinesite attached the double’s arm to Rockwell’s Sam 2 through careful rotoscoping and warping of clothing.



flashing lights, bleacher beacons, police lights — to drop back into the miniature, anything to keep it from looking too static.”

A final postproduction tally had Cinesite’s contribution on *Moon* hovering at nearly 300 shots, with additional cleanup work and moon base monitor inserts provided by Molinare, which did the digital intermediate on the film. Always mindful of the budget, Duncan Jones found himself continually reshuffling and renegotiating those shots

throughout production. “It was a strange experience, really, because I was almost working in a producer capacity half the time,” Jones reflected. “I knew what shots I wanted to do, but then I’d have to really negotiate with Cinesite and work out when we could afford to do them. A lot of the time, we were just making those decisions on the set. So if we were running a bit high on effects shots, I’d have to pull back. Then if we got back on track, I’d put more in. It really was a matter of give and take, made possible because Simon and his producer, Angie Wills, were actually on the shoot with us, and they were very flexible. We had a really good relationship, and I think they had a lot of trust that I would keep to our agreed budget.”

In the end, the limitations of that budget, along with the passion and resourcefulness of all the people involved, helped define *Moon*’s unique style, and its achievement as a refreshing antidote to the often over-budgeted and under-conceived films that have come to define modern movie-making. “I’ve been trying to get my own stuff off the ground for years,” commented Bill Pearson, “and these bastards managed to do it! But I’m so pleased they did, because in 32 years in this business, *Moon* is the movie I’m most proud of. When I saw the final result, Duncan was standing outside in the lobby looking absolutely knackered, and I walked up to him and said: ‘Good show. Bloody good show!’”

A scene featuring the two Sams in a game of table tennis was shot entirely with a locked-off camera. Rockwell as Sam 1 (in baseball cap) was first filmed miming the action of the game, which concluded with a lunge across the table, knocking it out of position. The table was left in the offset position, and, with just one take to get it right, Rockwell then delivered a perfect performance for Sam 2 that precisely mirrored the actions of Sam 1, including dodging out of the way of the knocked table. Cinesite speed-shifted the edited footage to interpolate more smoothly between frames, and tracked a 2D-animated ping-pong ball into the shot to complete the gag.

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Infernal Designs

ARTICLE BY JOE FORDHAM

When Columbia Pictures set out to adapt Dan Brown's mystery thriller, *The Da Vinci Code*, it was a given that, if audiences voted with their ticket stubs, the door would be open to an adaptation of its prequel, *Angels & Demons*. Director Ron Howard and screenwriter Akiva Goldsman were eager to return, reuniting with their U.K. production team. "Ron Howard got on really well with Dan Brown," remarked visual effects supervisor Angus Bickerton, "but whereas on the last film Ron felt very keenly that he had to be faithful to the book, he decided with *Angels & Demons* that he was going to take the book as a *Outland* as he segued into features directing with *Moon* – his whereas on the last film Ron felt very keenly that he had to be faithful to the book, he decided with *Angels & Demons* that he was going to take the book as a starting point, and not be beholden to every detail. This movie plays as a sequel, rather than a prequel. We sped up a lot of the book's early exposition, and downplayed or removed some of the more far-fetched elements. This one was much more a race-against-the-clock thriller."



Angels & Demons begins with a pope's funeral procession through the Basilica and Saint Peter's Square in the heart of Vatican City. When Roman Catholic censure of the Dan Brown source novel rendered most holy locations off-limits, director Ron Howard and his team turned to methods that had enabled them to overcome similar restrictions when making Brown's *The Da Vinci Code*, using partial sets and digital extensions. Visual effects supervisor Angus Bickerton and many members of the *Da Vinci* crew reunited for the project, including Double Negative, which handled Vatican exteriors.

The film pits Harvard symbologist Robert Langdon (Tom Hanks) against the Illuminati, an ancient secret society of atheistic scholars, which appears to be responsible for a string of murders beginning in CERN nuclear research center in Switzerland. Langdon teams with physicist Vittoria Vetra (Ayelet Zurer) and a young Vatican priest, Camerlengo Patrick McKenna (Ewan McGregor), to prevent both the deaths and the detonation of an antimatter bomb in Rome.



Production designer Allan Cameron built an expansive forced-perspective set, representing portions of Vatican exteriors, at Hollywood Park racetrack in Los Angeles. Double Negative used lidar scans of sets to plan digital extensions, and, operating ostensibly as tourists, gathered high-resolution digital stills of Vatican structures. The quarter-million images became the basis for photogrammetry reconstructions using Double Negative's custom 3D image reconstruction tools. Double Negative populated the Piazza with onlookers, expanding 500 extras to approximately 300,000 using 2D replication techniques together with CG crowd simulation.

The story's themes of science versus religion precluded Vatican cooperation, so the filmmakers explored visual effects techniques previously used to recreate an off-limits location for *Da Vinci Code*. "We used what was essentially digimatte methodology," Bickerton recalled. "Rainmaker UK took daylit pictures of a church in Paris, tourist-style, then turned those textures into moonlight by matte painting the lighting onto low-resolution geometry of the set. It was very successful, and it was a revelation to our producers." Executive producer Todd Hallowell discussed using the technique on a larger scale in Rome, and commissioned location scouts to gather material to create virtual reality surveys of potential locations. "We built up a massive photo library of all the key locations in the book and used them to make Apple QuickTime VRs. We sent those off to Akiva Goldsman, who was writing the script, so he could see all the locations and pan around them."

Production designer Allan Cameron researched sites large enough to accommodate partial Vatican exterior sets. Cameron selected QinetiQ, a former Ministry of Defense testing ground in Surrey, and worked with previsualization studio Painting Practice in London to design forced perspective sets that combined full-scale foreground detail with smaller scale distant structures, designed for digital enhancement. Before construction began, however, the 2007 Writers Guild of America strike caused a hiatus in production and the filmmakers relocated to their home turf of Los Angeles. Angus Bickerton and visual effects producer Barrie Hemsley scouted visual effects vendors, visiting 22 companies over a three-week period. Ultimately, faced with twice the shot count of *Da Vinci Code*, they awarded work to companies they had used on the previous film.

Principal photography began with four weeks of location work in Rome, avoiding Vatican City. Filming continued on interior sets at Sony Pictures Studios, in Culver City, and on a vast outdoor lot at Hollywood Park racetrack. "Allan Cameron built about one third of the front of the façade of the Basilica in Hollywood Park," related Bickerton. "He also built one third of one side of the curving colonnades around the square, taking some liberties with scale. We built the area around the obelisk in the center of the square, but the needle only went up halfway, to 30 feet. Then we had

what we called the ‘media buildings,’ rectangular structures at the end of the Via della Conciliazione approach road that leads into the piazza.”

To lay the foundations for digital set extensions, Gentle Giant and Plowman Craven Associates conducted lidar scans of the sets. Double Negative used the data, location photographs and a low-resolution commercial 3D model of Rome to guide shooting. “Our pipeline relied pretty heavily on photographic details from textures,” stated Double Negative visual effects supervisor Ryan Cook. “We just used the commercial model for previz. Angus and visual effects art director Aaron Haye provided us with art department models of the LA sets, and we built a previz model as close as possible to the way things were positioned in Hollywood Park. We combined that with cycloramas based on still images of the real Saint Peter’s. I lined up the model with the angles we were shooting and output still frames so Angus and the crew could get an idea of what we’d be seeing in final shots.”

To gather detailed photographic material for 3D set extensions, Double Negative visual effects producer Fay McConkey accompanied a small team to Italy to photograph high-resolution digital stills of Vatican structures. Operating ostensibly as tourists, without tripods or architectural survey tools, the team discreetly captured bracketed exposures of buildings around Saint Peter’s Square. The quarter-million images fed into Double Negative’s in-house 3D image reconstruction photogrammetry tool, dnPhotofit. “We picked points on the photographs,” explained Double Negative CG supervisor Graham Jack. “Photofit worked out where the points were in relation to each other in physical space. Normally, we would then fit the photography to lidar data of the environment geometry; but this time we used photography to generate 3D points that we built the models from, and then we fit photographs to the model.”

The production also conducted a helicopter shoot over Rome to capture daylight aerial textures above Vatican airspace. Double Negative used high-resolution satellite imagery to assist layouts, and then embellished foreground structures. “We modeled all the statues, balustrades and columns,” related Jack. “We then added details derived from the photographic textures. Pretty much every shot was 3D rendered. We built a CG Basilica and neighboring buildings. Further back, some of the background relied more on 2D textures, with matte paintings re-projected onto building geometry. Beyond that, it was pure matte painting.” The digital Vatican exterior became the basis for ten completely digital aerial shots of the city. In more than 200 shots, the model served as the basis for set extensions that Double Negative 2D supervisor Victor Wade adjusted to fit the forced perspective set in Hollywood Park.



The opening of the film crosscuts events at CERN nuclear research center in Geneva, where a scientist is murdered and a sample of his experimental work stolen. CERN allowed the filmmakers full access to its facilities, including the ATLAS particle collision detector. The Moving Picture Company conducted photo surveys and used textures to detail geometry derived from CERN’s own model of the huge machine. At Sony Studios in Culver City, Allan Cameron built sets representing a fictional control room with a gallery window backed by greenscreen, into which MPC composited its model of the ATLAS detector.

For sequences inside the vast 16th-century Saint Peter's Basilica, CIS Vancouver visited the location to gather photographic textures. "When we walked into the Basilica," noted CIS visual effects supervisor Mark Breakspear, "my two initial emotions were awe and terror. It's the biggest church on earth, and it's all made up of mosaic tiles. That is not apparent from photographs, but when we got in close to the great big paintings and started taking pictures, we saw all the surfaces were made up of little ceramic squares, billions of them. The building was so big, there was a graying effect that you usually see when you look out over distant mountains."

To gather photo surveys, CIS used 22-megapixel Canon EOS digital SLRs and a 35mm camera containing Kodak 5218 motion picture film, the same stock that director of photography Salvatore Totino used to shoot the film. "By shooting single frames on film," said Breakspear, "we protected the dynamic range of images in the church. When we scanned that negative, it gave us 6K images and we multimedia-mixed that with our digital stills to give real depth to our shots using the same grain structure as the rest of the movie." CIS discreetly photographed thousands of high-dynamic range bracketed images, in ambient light, without tripods, focusing on areas of high detail, including the Baldacchino, a 17th-century sculpture of four 65-foot-tall columns supporting an ornate metal canopy above Saint Peter's burial site. The architecture department at John Cabot University in Rome helped locate Basilica blueprints, which assisted construction of 3D models, but ultimately CIS derived them from photo surveys.

Allan Cameron's team built partial Basilica interiors in Culver City. "The Basilica set was minimal," commented Angus Bickerton. "We had the floor, and an area called the Confessio — which contained a stairway that led under the Baldacchino into a crypt where all the past popes are interred. There was a truncated section of the nave, floor only, a little bit of the doors to the piazza, and one column base." PCA captured lidar data of the set, which CIS used to align practical set pieces with 3D set extensions. After principal photography, CIS returned to Rome to capture photographic textures inside the Basilica specific to camera angles in the production shoot.

CIS CG supervisor Karen Ansel and compositing supervisor Martyn Culpitt then oversaw digital image reconstruction. Each texture involved at least three exposures to give artists the ability to minimize highlights, or maximize shaded areas. Paint and texture artists first removed tourists, which generally filled the lower third of every shot, then painted out specularity on surfaces, resulting in a flat, ambient-lit image. CIS then applied textures to its 3D model. "The Basilica was too massive to render as a complex model," stated Mark Breakspear, "so we built detail where needed, letting texture do the work on other surfaces. We wrote a shader to render mosaics that were most visible to camera, creating bumps and irregular edges that shimmered as they caught the light." Basilica floors made up of thousands of marble slabs in sculpted



The CERN sequence included a dramatization of the creation of antimatter. MPC generated the sequence as a frenetic 40-second shot that began in the ATLAS control room, re-created as a camera-projected environment, which transitioned to a series of computer generated environments. The segment included a stylized x-ray view of the ATLAS collider and a roller-coaster journey following streams of antimatter particles, realized as particle effects. The camera then raced out into a tunnel housing accelerator pipes, derived from photographs of the

patterns required special attention. “The marble had worn down more in some areas, creating undulations, divots, dents and scratches, which were all slightly reflective. We spent a lot of time getting those to look right, painting out existing lighting and adding our own.”

accelerator tunnel at CERN, and arrived at a practical prop of a collection canister.

The Vatican is first seen in the opening of the film during the funeral of the pope. CIS filled the Basilica with throngs of onlookers using foreground performers and digital doubles. “We shot plate elements of extras against greenscreen in L.A.,” said Breakspear, “then we projected those crowds onto simple shapes so we could place them at the correct angles in our shots.”

Exteriors featured the procession of the funeral cortège surrounded by approximately 300,000 onlookers. The production shot 500 extras in the Hollywood Park set to represent the throng, and Double Negative then created crowd enhancements using Gentle Giant cyberscans and HD footage of extras in varieties of costumes, behaviors and lighting conditions. For generic crowds without dramatic camera moves, Victor Wade’s team used textures as sprites populated around the piazza. For more specific crowd action, Double Negative employed its CG crowd system, Mob. “Mob is a particle-based system in Houdini,” stated Graham Jack. “We used particle simulations to create character paths, and then Mob integrated motion capture clips and made sure that characters’ feet stuck to the floor. It then output that into a motion database, which we loaded into Maya and used to position and light the crowd.” Compositors detailed scenes with CG pigeons, postcard stands, cars and TV antennas layered with atmospheric effects.

The funeral crosscuts events at CERN, and the discovery of a scientist’s mutilated corpse, its flesh seared with a cryptic brand. Makeup department head John Blake worked with Alterian Inc. to create prosthetics representing charred symbols burnt into the flesh of murder victims seen throughout the movie. “The prop department made several metal branding irons,” said Alterian makeup effects supervisor Tony Gardner. “We made molds and cast urethane copies of the ends of the brands, and John Blake pressed those into a flat surface of warm clay. He and makeup effects artist Stephen Prouty sculpted burned skin around the edges and added texture into the depressed burned area, and we manufactured mass-production molds to cast prosthetics for the actors to wear.” Alterian cast the appliances in flesh-colored silicone using transparent silicone molds. “John Blake could hold a mold up against the actor’s chest and see through it to place the brand exactly where we wanted it on the skin. The mold retained the structural integrity of the prosthetic so the edges didn’t wrinkle while he glued it down.” For the death at CERN, Alterian supplied throat-slash and gouged-eye



Camerlengo Patrick McKenna (Ewan McGregor) accompanies cardinals entrusted with the election of the next pontiff in a secret ceremony – a Papal Conclave – that takes place in the Sistine Chapel. Allan Cameron built the lower portions of the Sistine Chapel extending to the base of the window frames, and a staircase leading to the Sala Regia antechamber. MPC generated extensions to the Sistine Chapel ceiling using file images collated from tourist photography, and extended the staircase set by compositing a corridor extension into a greenscreen at the base of the steps.

prosthetics and dummy eyeball pieces. The production's in-house compositing team then deepened the wound by tracking in a 3D eye-socket texture to the performer's head.

CERN allowed the filmmakers full access to its facilities prior to the activation of its Large Hadron Collider — a 17-mile-circumference particle accelerator buried 575 feet under countryside neighboring the Alps. The production made several visits to Geneva to gather survey data, and recreated the environment on Culver City sets enhanced with digital extensions generated at The Moving Picture Company.

For an establishing shot of the sprawling facility, MPC generated a digital matte painting using high-definition RED camera footage that Angus Bickerton shot on location. Matte artists grouped administrative buildings closer to a warehouse-sized structure that housed an access tunnel to the 7,000-ton ATLAS particle collision detector. "There was a massive hole in the ground where they lowered machinery to construct it," explained MPC visual effects supervisor Richard Stammers. "Our CG supervisor, Kevin Hahn, and environment lead Vlad Holst created a camera move down the hole through a series of dissolves that started looking out past CERN buildings at the large hangar door. We built a 2½D matte painting using 3D geometry and re-projected textures, then placed mountains behind that."



While cardinals deliberate – and a stolen antimatter bomb hidden somewhere in the Vatican ticks down to detonation – Harvard symbologist Robert Langdon (Tom Hanks) races to gather ancient clues in Roman architecture. The first port of call is the Pantheon, a circular domed chamber and popular tourist venue. Ron Howard filmed performers arriving at the exterior of the actual structure in Rome. Allan Cameron then built a partial interior set in Culver City.

To plan coverage of the ATLAS detector, Bickerton collaborated with Painting Practice to create an animatic using reconnaissance photographs of the location. Bickerton then returned with visual effects coordinator Holly Gosnell and camera operator Rory Hinds to shoot RED camera footage. “It’s hard to convey the feelings that wash over you at the monumental size of CERN,” stated Angus Bickerton. “It’s like an Apollo mission that took ten years to build; and I wanted to convey that scale. Paul Docherty at Peerless Camera Company gave me the idea of using an Arriflex Ultra Prime 8R rectilinear lens. It captures extreme wide angles, but has incredible optics that remove fisheye distortion. We put that on the RED camera, dropped down into this phenomenal maze of gantries and pipes and girders, and shot 4K plates.” Crane shots achieved with the RED camera mounted to a Stanton Jimmy Jib with a Power-Pod 2000 remote head allowed Bickerton and crew to create sweeping camera moves in tight quarters.

To cover all possible angles of ATLAS, MPC shot still images as textures that could be projected onto 3D geometry. “CERN provided a CG model that was so enormous it almost killed Maya trying to open it,” related Richard Stammers. “The detector was a huge barrel-shape device about 25 meters in diameter and about 40 meters in length, with layers of very densely packed panels that detected particle paths, and various magnets that caused them to bend, so it could detect their mass. We worked a lot of those technical details into our shots.”

Back in Culver City, Allan Cameron’s team built sets representing CERN laboratories and tunnels, and a control room with a gallery window looking onto greenscreen. MPC then composited its digital re-creation of the ATLAS detector into the control room window, and dramatized the creation of antimatter. “Ron Howard and Angus wanted to make the process of collecting antimatter understandable for an audience,” observed Stammers. “We came up with a brief sequence to explain how various types of particles are produced as a by-product of multiple collisions that, in reality, happen millions of times a second. We focused on one collision and how it provided a harvest of antimatter protons, which then got stored in a canister.”

The 40-second shot, tracing the birth of a particle of antimatter, began in the control room set. MPC re-created the set as a camera-projected environment, which transitioned to a series of digital models. The camera passed through the control room window into the ATLAS detector, image-modeled from CERN textures and dressed with 3D scaffolding and pipes. The shot then transitioned to a stylized x-ray view of the inner workings of the collider, and traveled with streams of antiprotons, realized as particle effects. The camera then pulled out into a tunnel housing accelerator pipes and decelerated to reveal antiprotons siphoned into a larger-scale pipe, which led to a collection canister — a practical prop in another Culver City set.



The Senate Visual Effects created extensions to the set using still photography of the Pantheon in Rome, lidar scans of the Culver City set, and archival data relating to the building’s dimensions.

Visualizing antimatter particles in the canister required a degree of dramatic license, and included practical elements shot at Mattes and Miniatures, at Bray Studios in England. “We fired a high-powered green laser into a piece of clear-cast acrylic,” related miniature effects supervisor Leigh Took. “The acrylic was in the shape of a skull that we had lying around, but it refracted the light really well onto a flat white screen in darkness shot at very low exposure. We put the skull on a model-mover that rotated very slowly; and as the beam went through the eye sockets, it refracted and created amazing shifting organic webbing effects.”

MPC combined laser light elements with digital simulation effects. “The laser elements were beautiful,” observed Richard Stammers. “We took some of the slower-moving textures and emitted an aura as a particle simulation generated through the luminance of the laser texture. We further embellished that by copying the green color channel into the red and blue channels and offset them by two or three frames, which created a lovely temporal chromatic aberration effect. Toward the end of the film, the containment canister starts to fail and the magnetic field holding the antimatter in suspension deteriorates, so the antimatter becomes agitated, and we made the aura surrounding it violently flicker with lens flares.”

The antimatter, hidden in the Vatican, threatens a Papal Conclave, where cardinals have assembled to elect the next pope in a secret meeting in the Sistine Chapel. The production built a Culver City set representing lower portions of the chapel, side walls extending 30 feet to the base of the windows and an end wall rising approximately 50 feet, adorned with a reproduction of Michelangelo’s *The Last Judgment*. MPC digitally extended the set, adding windows and a giant vaulted ceiling with other biblical frescoes created from digital still photography of the location. “We used source file photos from tourists,” said Stammers. “Many of them were poor quality, underexposed and motion blurred, because light levels were so low. But when we collated them, they were incredibly useful. We did an image model build from those, which gave us our basic geometry, and aligned our geometry with the practical set.”

Outside the Vatican, Langdon and Vittoria race between four sacred sites in Rome, filmed as mixtures of location photography, Los Angeles sets and digital extensions. The first, the Pantheon, was a 142-foot-wide circular domed chamber with adjoining aedicules and an oculus at the apex of the dome. “The Pantheon was a repeating shape,” noted Angus Bickerton, “so Allan Cameron built two aedicules and one chapel at full-scale, and then we extended the rest.”

The Senate Visual Effects shot digital still photography of the Pantheon interior, which became the basis for digital extensions and more detailed builds of Rafael’s tomb, seven chapels and eight aedicules. “We used an art department CG model to previz the scene,” explained Senate visual effects supervisor Richard Higham. “Once the previz was approved, it became obvious the whole environment needed very high-detailed geometry and textures. We used lidar geometry of the L.A. set and archival information that was available online to align our CG to the live-action.” To assist with generating 3D camera perspectives, the production attached a Canon HF10 HD camera to the motion picture camera, providing *The Senate* with an additional wide-angle perspective of the scene. “The production camera was close on the actors with a 70mm, and in some cases a 190mm, lens. That left us with no floor, and just the tracking markers on the greenscreen as reference. In those

situations, the HD camera gave us an alternative camera angle, very close to the original camera, providing just enough information to reproduce a decent camera track.”

The Senate CG supervisor Daniel Canfora lit the Pantheon using high dynamic range images, volumetric light beams and CG dust particles rendered in mental ray. Compositors blended multiple 3D passes including shadow, specular and ambient occlusion. To populate shots with tourists, The Senate added motion control elements of performers, some of which were shot with a motion control crane, and then 3D-tracked elements into the scene.



Langdon and Vatican security arrive too late to prevent the horrific murder of Cardinal Guidera in Santa Maria della Vittoria church. The scene was shot on a partial set using a bonfire of church pews built out of metal, rigged with flames. Alterian Inc. supplied silicone prosthetics representing a cryptic brand seared into the cardinal's chest, and for wide shots provided a likeness dummy rigged to writhe. CIS Vancouver added repeat passelements of roaring flames and set extensions.

Langdon and Vittoria discover the Illuminati's first victim, branded and suffocated with earth, in a subterranean chapel inside Santa Maria del Popolo church. The off-limits location in Rome was adjacent to an almost identical structure, a police station, which the production used to double exterior views. The Senate shot photo surveys of del Popolo, and digitally transformed the police station building, adding the church tower, dome and digital textures to match lighting in the production plate. For Popolo interiors, Allan Cameron's team built a partial set in Culver City, with walls dressed with scaffolding representing the church under renovation. CIS Vancouver extended walls and ceilings using still camera textures shot in Rome and tracked in 3D extensions to scaffolding.

The second murder occurs at night at the foot of the obelisk in Saint Peter's Square, where Cardinal Lamassé expires, branded and pierced with fatal puncture wounds through his lungs. The production filmed the death scene in Hollywood Park, with a prosthetic rigged with air and blood tubing covering the victim's chest and torso. Double Negative extended architecture, and added crowd and optical effects. "The square was quite brightly lit, even at night," observed Double Negative compositor Paul Norris. "We added lighting effects in CG — lens flares, and edge flaring — to make it look like everything was filmed in-camera, with a chaotic long-lens feel. HD witness cameras on the production cameras gave us a wide-angle view of the set not occluded by crowd. Our matchmove team then used photogrammetric software to calibrate between the video and film cameras, and that helped lock our CG elements to the camera movement."

Langdon discovers the third murder victim inside Santa Maria della Vittoria, another church, where Cardinal Guidera is burnt alive, suspended above a bonfire of burning church pews. Allan Cameron built a set at Hollywood Park representing the della Vittoria doorway, and then created the interior as a redress of the del Popolo church interior set. "The two churches were quite different in scale," observed Angus Bickerton, "but Allan worked out a floor plan that was an aggregate of the two so we could go from del Popolo — removing all its scaffolding and plastic sheeting — and then redress it as della Vittoria."

The fire inside the church was a full-scale practical pyrotechnic effect created jointly by U.K. special effects supervisor Dominic Tuohy and special effects supervisor Clay Pinney and his team in Culver City. "Dominic built the bonfire in the U.K. when we were gearing up to shoot there," explained Bickerton. "The stacked-up pews, which looked like wood, were actually made of metal and went together like pie-sections. Dominic then plumbed that with flame bars and gas pipes. We shipped



Angus Bickerton inspects a replica of the church ceiling, built by Mattes and Miniatures. Bickerton lit the miniature with flame-colored light and filled the ceiling with smoke. CIS Vancouver then tracked the element into plates.

that to L.A., and Clay rigged it all on set. We took the whole thing onto a backlot, cranked the fire up to '11' and shot repeat angles so we could composite even more flames on top."



Langdon and associate Vittoria Vetra (Ayelet Zurer) watch Camerlengo McKenna pilot a helicopter, lifting off from Saint Peter's Square, carrying the antimatter bomb from its hiding place in the Vatican. Ron Howard filmed the helicopter liftoff on the partial set at Hollywood Park, using 300 extras to represent onlookers, backed by greenscreen. Special effects supervisor Clay Pinney's team rigged a helicopter mockup, suspending a rotor-less helicopter body from a crane.



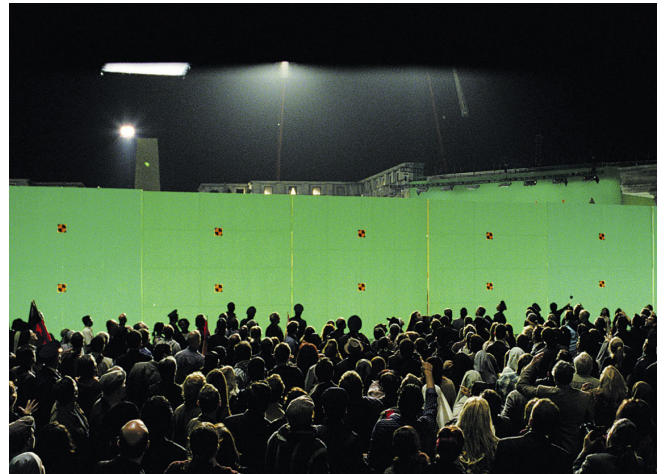
Double Negative digitally removed helicopter rigging and added rotors and engine exhaust heat shimmer. Environment extensions included the breadth of Saint Peter's Square, an extension to the central obelisk, and surrounding structures.

Alterian applied a silicone prosthetic branding makeup to stuntman Bob Yerkes' chest, and created a weighted likeness dummy designed for use in wide shots. The dummy contained a loose-jointed armature, and a head mechanized to roll using a battery-powered drill motor buried in the neck. Alterian shop foreman Tim Huizing led puppeteers manipulating cables to make the body writhe.

To depict an ornate ceiling filled with smoke above the cardinal, Mattes and Miniatures built a 1/3-scale miniature set extension. "The miniature was about seven feet deep and included the tops of columns and the ceiling arch," observed Leigh Took. "We built it out of bent-skin plywood, and created frescoes using photographs of the church in Rome. The photos had been taken from ground level and they had perspective distortions, so we corrected those in Photoshop, printed them out, wallpapered them onto the miniature and retouched them to create a hand-painted texture." Modelmakers detailed the ceiling with sculpted cherubs and angels cast in Fastcast resin. Angus Bickerton then filmed smoke roiling up into the rafters, at high camera speeds, lit with interactive flame-colored light.

CIS Vancouver tracked the model ceiling into shots, added CG smoke, blended interior and exterior bonfire elements, and digitally enhanced the live stunt performer. "They filmed the stuntman over the fire from a forced perspective," said Mark Breakspear. "It looked like he was over the flames; but, in fact, he was ten feet behind. We brought him forward and placed fire a little bit behind him so he seemed to be among the flames." Angus Bickerton shot RED camera elements of controlled burns on another stunt double and blowtorched a chunk of pig flesh. CIS tracked flame elements to the cardinal and warped the pig flesh texture to a scan of the performer's head.

The fourth murder takes place in Piazza Navona at the Fountain of the Four Rivers, where Langdon attempts to prevent the drowning of Cardinal



The crowd in Saint Peter's Square observes the helicopter ascend and disappear into clouds. Previz determined that despite the enormous size of the Piazza, fewer than 500 extras would fill the foreground in the forced-perspective set at Hollywood Park. Double Negative generated background crowds in static shots by replicating 2D crowd elements. For shots requiring more dynamic moves or crowd behavior, Double Negative gathered motion capture data of stunt performers and used the motion clips to generate 3D crowd simulations. Double Negative also enhanced the live foreground crowd with digital extras generated from cyberscans and high-definition greenscreen elements of extras filmed in Hollywood Park.



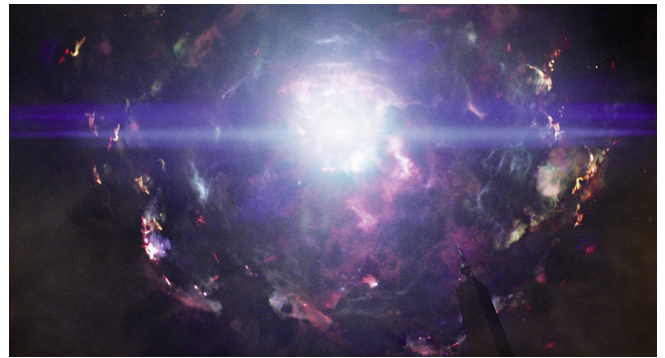
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Baggia. Ron Howard shot Tom Hanks entering the location in Rome and continued the action on a perspective-scaled partial set in Hollywood Park.

generated from cyberscans and high-definition greenscreen elements of extras filmed in Hollywood Park.

Alterian supplied a weighted likeness dummy of Baggia, made from urethane foam with a silicone skin, which performers grappled with in a fountain on set. MPC created environment extensions based on photographic surveys of the location and lidar surveys of the set that matchmove supervisor Jigesh Gajjar and 2D supervisor Richard Baker matched to plates.

Langdon's race back to the Vatican, in anticipation of the antimatter explosion, featured a pursuit from Castel Sant'Angelo across an elevated walkway into Vatican City known as the Passetto. MPC generated a high angle, rotating camera shot establishing the castle and its proximity to the Basilica. The shot originated with tiled motion picture plates filmed from the Castel Sant'Angelo roof, overlooking Rome. Richard Baker stitched the plates together, creating a 2D environment in Nuke, and imported a 3D camera move around a digital model of a stone angel atop the castle.



Antimatter explodes in the sky above Saint Peter's Square. Double Negative initially developed tests for the sequence based on footage of airborne nuclear weapons tests. After ruminating on the concept, Ron Howard called for a new approach based on celestial phenomena. Double Negative studied deep-space imagery and created new conceptual art depicting a cataclysmic blast of galactic scale. The final effect included elements that Double Negative generated using its custom fluid simulation tool and volumetric renderer.

For shots of Langdon and Vittoria running along the Passetto, Bickerton and MPC mounted a Canon D1S Mark II digital SLR to a small motion control rig and shot 360-degree panoramic daylit backgrounds from 12 positions along the narrow walkway. They then repeated the process at night, and PCA recorded lidar data of the environment, capturing geometry of neighboring residential buildings. Allan Cameron built a partial section of the walkway, approximately 100 feet long, in Culver City, where Ron Howard shot Hanks and Zurer running. MPC then extended the set using 3D geometry, and blended nighttime textures with 15-percent fill of daytime textures, creating a moonlit night effect. Midground buildings were 3D objects projected with photographic textures, while the Basilica dome and more distant Roman architecture were layered onto cards.

The climax of the film involves Camerlengo McKenna carrying the antimatter bomb from its hiding place in the Vatican to a helicopter, which he pilots above the city where the device detonates. The production filmed the helicopter takeoff from the Basilica steps in Hollywood Park using a helicopter mockup that Clay Pinney's team suspended from a cable-hung gimbal. Double Negative digitally removed effects rigging, added helicopter rotors and engine exhaust heat shimmer, and expanded Saint Peter's Square to encompass more than 100,000 onlookers. For shots of the helicopter ascending over Rome, Double Negative created an entirely CG helicopter, and fully synthetic aerial views of the city.

For helicopter interiors, Ron Howard filmed Ewan McGregor riding in the helicopter mockup on a Culver City soundstage. The antimatter canister — made out of milled metal with a plastic

transparent center — contained a light source, which created interactive glows, into which MPC animated flickering antimatter simulations. For the antimatter's detonation above the Vatican, Mattes and Miniatures created a pyrotechnic effect using a miniature helicopter buck, which Double Negative worked into the initiating moments of its digital explosion.

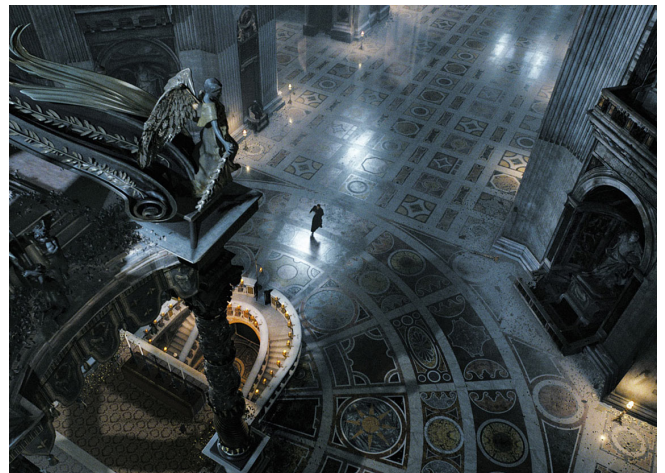
Design for the antimatter explosion began with reference to nuclear detonations, until Ron Howard called for a revised concept that focused more on the story's metaphysical themes. "We looked at images of supernova and Hubble space telescope imagery," noted Ryan Cook. "The biggest challenge was creating an event that appeared to have galactic scale that wouldn't look like it was going to kill everyone in Saint Peter's Square. One of our matte painters, Christoph Unger, worked up a new design concept that Ron liked. And we started working up elements using our in-house fluid simulation tool — dnSquirt — and our volumetric renderer, DNB."

The event begins in cloud cover with the initial flash of the helicopter's explosion, which implodes and rapidly expands. "We were able to draw on a lot of our earlier research into nuclear bomb reference in terms of how clouds reacted," noted Paul Norris. "They evaporate, rather than get pushed away, which helped create a feeling of impact and danger." The event also took its cue from lighting effects of the crowd reacting at ground level, filmed in Hollywood Park. "They had used a bright-white lightning flash effect on set. We matched that in the core of the explosion, with a little bit of blue to make it feel white-hot, and then added a lot of subtle coloring and detail to the energy expansion. That included some of Angus' laser elements in the early part of the effect, but on a very violent, massive scale."

The detonation illuminates Rome, which Double Negative created using 3D models of foreground architecture, CG Basilica and neighboring buildings, and a 3D River Tiber, textured to reflect the glare. Buildings further away involved photogrammetric structures lit with re-projected textures, with matte paintings in the distance. The shockwave then flattens the crowd as it impacts the ground. "We called it the 'Field of Corn' shot," remarked Graham Jack. "We generated the crowd in Mob, and created the expanding shockwave in Houdini. We did a



The shockwave causes frescoes to crack and fall within the Basilica. For a shot of rubble crashing to the floor, Mattes and Miniatures built a black buck re-creation of the location. Modelmakers positioned bags of dust and plaster above the set and triggered their release, causing a rain of debris to fall and rush toward camera. CIS Vancouver integrated the element into the moonlit digital Basilica.



Miraculously, Camerlengo McKenna survives the antimatter explosion and revives, seemingly deranged, to flee to a crypt in the Basilica. Allan Cameron built a minimal set representing a portion of the Basilica floor, Confessio and the base of one column. CIS Vancouver completed the expansive environment with a 3D reconstruction derived from photo imagery.

motion capture shoot with a stunt crew on wires to capture actions of people being thrown through the air. As the shockwave traveled through the crowd, it triggered those motion capture clips; and the tools we wrote inside Houdini ensured the actions moved in the correct direction. We then added interactive dust and debris effects.”

Inside Saint Peter’s Basilica, frescoes crack and crumble. Leigh Took’s team created miniature crumbling fresco effects using pre-scored plaster pieces held in place by electromagnets and then released to break away on cue. For a wider shot of rubble crashing to the Basilica floor, Took’s team constructed a 25-foot-tall black buck miniature of the location and released bags of dust and plaster from overhead. CIS Vancouver integrated the practical element into the moonlit digital Basilica and composited dust rushing toward camera.

Having survived the blast, the camerlengo flees to a crypt in the Basilica and commits suicide by immolation. Ewan McGregor performed the immolation on a soundstage set in Culver City, miming the burn. Lighting gaffer Rafael Sánchez provided on-set interactive lighting using an array of light emitting diodes to project video footage of flickering flames onto McGregor and the set. A stunt double then stepped in to repeat the tail end of the performance as a full-body burn. The same double later returned for an additional pyrotechnic shoot, matching cut footage of McGregor’s performance. CIS Vancouver utilized re-speeds and warping effects to align the flames to McGregor’s body, and added digital heat haze shimmer, CG embers and CG smoke emanating from his character’s eyes and mouth.

The success of *Angels & Demons*, building upon the phenomenon of *The Da Vinci Code*, paves the way for a cinema adaptation of the third Langdon adventure, based on Dan Brown’s soon-to-be-published *The Lost Symbol*, should the production team reunite. “Ron Howard is consistently a gentleman,” remarked Angus Bickerton. “He trusts his team and he lets people do their thing. He is very specific about story points and what he wants out of a shot; but beyond that, he goes with your judgment. I think that helped us all deliver what we set out to do. We were augmenting a thriller, building it up a bit, and putting a dressing on it, while Langdon gets down and dirty — and believably remains a Harvard academic!”



The new pope steps out onto the Vatican Palace balcony overlooking Saint Peter’s Square. Double Negative composited foreground performers against a synthetic recreation of the Piazza and Rome. To gather aerial textures for overviews of the city, the production conducted a helicopter shoot above Vatican airspace, maintaining an altitude of no less than 500 feet. Double Negative used high-resolution satellite imagery to assist layouts, and ultimately modeled the city by hand, layering 3D and 2D textures in diminishing perspectives.

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A New Enterprise

ARTICLE BY JOE FORDHAM

After 40 years, six television series and ten motion pictures, Gene Roddenberry's *Star Trek* had appeared to run out of steam when Paramount Pictures turned to writer, director and producer J.J. Abrams — a prolific television series creator, recently turned feature filmmaker — to revitalize its flagship science fiction franchise. Abrams teamed with producing partners Damon Lindelof and Bryan Burk, and with screenwriters Roberto Orci and Alex Kurtzman, to provide a new take on the *Star Trek* universe. “I wanted to respect what had come before,” asserted Abrams. “I didn’t want to be paralyzed by it, creatively. I was very fortunate that Roberto Orci, one of my writers, was a huge *Trek* fan. He made sure our story honored the series’ legacy. At the same time, I felt the movie had to work on a more urgent, visceral level as a stand-alone entity.” “That was critically important to me. But I didn’t want to be paralyzed by it, creatively. I was very fortunate that Roberto Orci, one of my writers, was a huge *Trek* fan. He made sure our story honored the series’ legacy. At the same time, I felt the movie had to work on a more urgent, visceral level as a stand-alone entity.”



Director J.J. Abrams briefs his cast on the set of *Star Trek*, a revamp of Gene Roddenberry's long-running television series and movie franchise. The new film focused on the origins of USS Enterprise captain James T. Kirk (Chris Pine) and Vulcan science officer Spock (Zachary Quinto). Joining in were many of Abrams' prior collaborators, including visualeffects supervisor Roger Guyett and Industrial Light & Magic, as well as a handful of additional effects vendors, special effects supervisor Burt Dalton, and two teams of special makeup artists, all pledged to reinvigorate the *Star Trek* universe.

The new film — titled simply *Star Trek* — explored the origins of starship Captain James T. Kirk (Chris Pine), his Vulcan science officer Spock (Zachary Quinto) and their crew. The young officers are thrown into their first adventure when an embittered Romulan captain, Nero (Eric Bana), uses a time-traveling spacecraft, the Narada, to seek out the annihilation of the United Federation of Planets and, in particular, the Vulcan race. Spectacular cosmic events ensue, including reality-shifting paradoxes, a planet-eating black hole, and the appearance of an elder Spock (Leonard Nimoy).



Junior officer Kirk assumes command of the Enterprise after Romulan invaders take the ship's captain, Christopher Pike (Bruce Greenwood), captive. Production designer Scott Chambliss modernized the familiar Enterprise bridge — built on stage at Paramount Studios — incorporating a panoramic forward viewscreen, composited by ILM, and live, open-interface displays furnished and operated during principal photography by Oooii. Oooii artists generated motion graphics and oversaw playback to 60 screen displays, including a 360-degree screen that wrapped around the bridge.

To prepare for the production, visual effects supervisor Roger Guyett — veteran of Abrams' debut feature, *Mission: Impossible III* — reacquainted himself with *Star Trek* history. "When I first came to Industrial Light & Magic," Guyett recalled, "John Knoll was supervising *Star Trek: First Contact*. Back then we were just entering the digital age, but they did some amazing work. In fact, the original series had an incredible history in visual effects, and I wanted to honor that, while at the same time adding new energy." Guyett reviewed all previous *Trek* features, and other space epics, and created a compilation reel of cinematic space technology. "*Star Trek* has always been based around principles of physics — a great deal has been written about the theories of what warp drive or a photon torpedo are. J.J. wanted to acknowledge that, but he didn't want his film to feel too retro. He wanted people to believe in the characters and events, which was at the heart of the original series."

Production designer Scott Chambliss — veteran of Abrams' TV drama *Felicity* — grounded the film in tangible reality by making extensive use of physical sets and locations. "We knew we'd have a lot of visual effects scenes that we could not originate on film," remarked Abrams, "but I desperately wanted this film to feel analog and real, and rooted in an emotional reality. Wherever possible, we found practical locations that we could either dress or use visual effects to enhance."

The filmmakers planned set construction on the Paramount lot and used locations in Utah, Alaska and Southern California. The USS Enterprise engineering levels were filmed at the Anheuser-Busch Budweiser brewery in Van Nuys, which allowed lengthy tracking shots through labyrinthine industrial interiors. Chambliss brainstormed production designs with teams of artists — Ryan Church and James Clyne leading ships and environments, Neville Page leading creatures — while previsualization lead David Dozoretz at Persistence of Vision and artists at The Third Floor generated animatics.

A focus of the production was the depiction of the Enterprise, configured to predate Walter Jeffries' 1965 design. "The idea was to make the Enterprise the ship that the casual viewer would recognize at first glance," said Abrams. "Those who were more familiar with the series would then see that there were significant differences. I wanted the ship to have a slightly more powerful quality, which

is why we made the nacelles larger. But mostly I wanted to retain the spirit of what Roddenberry had created and apply it to the context of modern technology.” Abrams considered the possibility of building the Enterprise as a practical miniature. “I still own the first Cinefex with images of the Enterprise in dry dock. I loved those models; and the idea of being on a set filled with atmosphere and little fiber optic floodlights was so romantic. But the reality of what is possible now digitally would have made that a vanity choice. We would have been doing something for the wrong reasons.”

As the Enterprise design took shape, ILM CG supervisor Tom Fejes oversaw construction of a highly detailed digital starship. “J.J. gave us the reins,” stated ILM art director Alex Jaeger. “He said, ‘You guys have been building this ship for two decades — add what you need to make it feel real.’ I had to walk the fine line between continuing what Scott Chambliss had set up for this chic, 1960s look and J.J.’s desire to see a tactile, functional ship.” The reconfigured ship was a larger vessel than previous manifestations — approximately 1,200-feet-long compared to the 947-foot ship of the original series. “Once we got the ship built and started putting it in environments, it felt too small. The shuttle bay gave us a clear relative scale — shuttlecraft initially appeared much bigger than we had imagined — so we bumped up the Enterprise scale, which gave her a grander feel and allowed us to include more detail.”

Digital model supervisor Bruce Holcomb and his team modeled the Enterprise and its internal mechanisms for an early scene of the ship under construction. “Once we had the silhouette of the ship,” said Roger Guyett, “we disassembled it and worked out the most commonsensical way to put it all together. Viewpaint supervisor Ron Woodall textured surfaces with interference paint schemes that reacted to light in certain ways, which was a technique used on the practical model for the first feature film.”

The Enterprise’s new features included an array of guns that emerged from the saucer section and a mechanical configuration that cued the ship’s jump to warp speed. “In the typical warp effect, lights get brighter and then the Enterprise rubberbands off into space,” commented Alex Jaeger. “J.J. wanted the ship to physically change its shape, from cruise to warp mode. We went through a lot of iterations to explore how much the Enterprise could change; but, in the end, we limited it to a couple of panels on the backs of the nacelles popping out, and the deflector dish opening up with its center piece mechanically protruding.”

The navigational deflector — a circular sensor array on the front of the secondary hull — was painted the same color as the ship for the first time in Trek history. “The original deflector dish had a copper finish,” noted Jaeger. “In later shows, it had an orange glow. We tried an orange glow on ours, but it looked out of place. It was the same with the nacelle caps: originally, we imagined what these could



In the opening of the film, the Federation starship USS Kelvin encounters a black hole, through which appears a gigantic Romulan vessel, the Narada. Concept artist James Clyne designed the Narada as a mining ship that had accumulated a forest of metal spires as a by-product of years of time travel through the black hole. ILM modeled the ship as a geometric form housing the main body and propulsion units toward the rear. Layers of prongs sweeping over the core shape formed a cocoon of organic shapes that engulf the Kelvin.

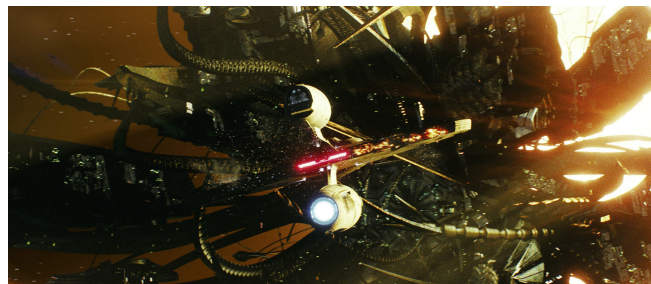
look like based on their description in *Star Trek* lore. We did a few versions of a translucent bubble filled with static electricity, to hint at the kind of motion they had in the old 1960s model, but J.J. thought it looked too ‘magical’ — he wanted it to feel physical. So we dumped that idea and kept the nacelle caps dark, with a little blue glow that ramped up when they went to warp. That, and the color of the deflector dish, gave the spaceship an almost monochromatic look that seemed very futuristic.”

On the bridge, ILM gave the main viewscreen a makeover to enhance interactions with outer space. “A big element of our task on this movie was generating scope,” commented Roger Guyett. “On the original series, the Enterprise bridge felt very enclosed. J.J. wanted to connect the characters more to the outside environment, so we added a panoramic window at the front of the bridge, which doubled as a heads-up display to show video while the characters were looking out into space.” ILM compositing supervisor Eddie Pasquarello layered reflections and elements into the viewer/window, and added motion graphics to other transparent screens around the deck.

The majority of screen displays on the Enterprise bridge were practical installations designed and operated by Oooii — motion graphics design and playback specialists, formerly known as Black Box Digital. “Our new company name stands for ‘Open Interface,’” explained Oooii creative lead Kent Demaine. “We expanded it to ‘Oooii’ to help people pronounce it phonetically. The concept of Open Interface is real-time visual effects — taking dynamic content generation programs and creating effects in what we call a ‘live environment.’” Oooii supplied 60 screen displays for the production, including an animating interface that wrapped around the Enterprise bridge. “Scott Chambliss wanted a seamless interactive display that went all the way around the set. We talked about using projectors, but there would have been restrictions as to where we could place them without actors walking through the beams. J.J. wanted the bridge to be a very high-key illuminated set, so we knew we needed the punch of an LED or LCD screen. We did a film test and ended up using a tile of Orion LCD screens.”

Chambliss configured the set designs to accommodate the LCD screens, while Oooii lead designer Jorge Alameda oversaw graphics creation using combinations of 2D Macromedia Flash and 3D applications to pre-generate elements. Oooii lead technical director Dave August then employed custom playback engines, based on videogame engine open graphics library technology, and a team of 12 Oooii operators piped imagery to set from off-camera workstations. “The goal was to create windows into a virtual workspace rather than rendering traditional interfaces,” noted Demaine. “That way, the content could appear to interact and travel dynamically across all the display surfaces.”

The Enterprise crew, and characters seen intermittently throughout the film, included alien



Lieutenant George Kirk (Chris Hemsworth), father of the future Jim Kirk, pilots the crippled Kelvin on a collision course with the Romulan ship. The Romulans open fire on the Kelvin with barbed projectiles that separate like cluster bombs and rip through the starship’s hull. ILM generated digital explosions using volumetric particle effects. To simulate pyrotechnic behavior in zero-gravity conditions, artists controlled the radial expansion of explosions and impact effects, rendering with multiple passes of fire, smoke, debris and sparks to emulate nonterrestrial dynamics.

ances generated as makeup effects at Proteus FX and Joel Harlow Designs, in collaboration with makeup department head Mindy Hall. Proteus initially recruited Harlow to join the team at its Pacoima studio, sculpting aliens and makeup concepts. “J.J. was open to a complete departure from what had come before,” said Proteus FX makeup effects supervisor Barney Burman, “but he wasn’t insistent upon it. We started flooding him with new designs, as well as images of characters from past *Star Treks*.” Two of Proteus’ earliest designs were homages to creatures created by effects artist Wah Chang for the classic *Star Trek* episodes “Arena” and “The Man Trap.” “We made the Gorn lizard guy, and the Salt Sucker. Funnily enough, neither design was met with much enthusiasm, maybe because they were throwbacks to the old show. We created those as midground ‘B’-characters. They were un-mechanized polyfoam-filled silicone pieces — which were quite heavy, but silicone gave us the look and movement J.J. wanted.”

Proteus created 36 creature designs — 12 foreground prosthetic makeups, 12 midground full-head masks, and 12 background pull-on masks. “We had 13 weeks to produce all the characters,” said Burman, “so we cranked out designs at our studio, working with Neville Page, who threw us a bunch of wonderful ideas, mostly as digital renderings in ZBrush.”

Page’s designs included creatures whose heads and necks defied human anatomy, visualized as prosthetic makeups incorporating digital effects. For Alnschloss K’Bentayr (Kasia Kowalczyk), an alien security officer seen in the film’s opening sequence, Proteus built a three-piece silicone head appliance, which ILM then manipulated digitally to create eye-blinks. ILM also created a digital prosthetic for an elegant alien nurse (Sonita Henry) by manipulating the actress’ features. “She had all the anatomy of a human,” said Roger Guyett, “but her eyes were much bigger. We applied 3D distortions to her face.”

Prominently featured on the bridge of the Enterprise was a character known as ‘Madeline’ (Kimberly Arland), a statuesque beauty with scarification-style markings. “Madeline looked like she had been hammered out of bronze,” related Barney Burman. “We used silicone appliances tinted with bronze metallic powders to keep application times down. Then it was just a matter of doing the detail work.” Makeup artists Margaret Prentice and Ned Neidhardt handled applications, which included silver corneal contact lenses created by Justin Stafford and prosthetic dentures of needle-like pointed teeth.

The makeup effects required a division of duties between the Proteus team and makeup designer Joel Harlow, who handled Vulcan and Romulan makeups. “We had already decided on an approach to creating Vulcan ears,” said Burman. “I did Photoshop designs and tests to show people how the makeups went together. Joel then took care of Vulcans and the Romulans on set. He set up a trailer with his own crew sculpting and designing Romulans on site so J.J. could see what was happening.”



In rural Iowa, a preteen Jim Kirk (Jimmy Bennett) joyrides in a Corvette and narrowly escapes a spinout into a quarry. J.J. Abrams filmed the climax of the sequence in a field, beside a 12-foot-deep, 30-foot-wide hole. The stunt team used a drag rig to pull the Corvette toward the hole as Kirk leapt clear. Burt Dalton’s special effects team then rigged the Corvette on a cable gimbal and swung the vehicle out over the precipice. ILM used the practical effect to initiate the car’s descent into a digimatte quarry, then transitioned to a digital vehicle as the Corvette fell away.

Vulcan makeups included two ages of Spock, and a variety of male and female characters. “We did 10 main Vulcans and a bunch of generics,” Joel Harlow explained. “Generic Vulcans included children, elders and every age in between. We sometimes didn’t get the actors until the morning of the shoot, so we had to sculpt Vulcan ears in all sizes and do random ear casts ahead of time. For the principals, we designed and cast ears specifically.” Spock ears proved to be a subtle art. “I went through five different sculptures and five different applications with Mr. Nimoy. This man, more than anyone, knows what the Vulcan ear should look like, so I was learning from the master. He told me the tip of the Vulcan ear should come forward gracefully, and that it was extremely important that it hug the side of the head. The ears couldn’t stick out — that’s what separates a Vulcan from an elf.”

Harlow sculpted prosthetics, with subtle veins and wrinkles, that fit over the top of Nimoy’s ears and extended halfway down the auricular helix. “Mr. Nimoy’s ears are a different shape than they were when he started the series,” noted Harlow. “One of the things I was fighting in the sculpture was to keep that trim, sleek look blended to his real ear.” Prosthetics were cast in silicone using a one-piece molding technique to generate seamless appliances. “We used a one-piece epoxy donut around a silicone mold. We filled the mold with silicone and clamped the epoxy donut around that, which held it in place but didn’t distort the sculpture. We then flexed the mold apart to pull out the prosthetic. It was the first time silicone had been used for Spock’s ears, and it gave them a nice translucency and fleshiness.”

Vulcan ear prosthetics for Zachary Quinto, which built up his less defined lobes and encompassed most of his ear, provided continuity between the younger Spock and Nimoy’s character. Mindy Hall shaved the actor’s eyebrows and added hair to create a 45-degree angle brow. Hair department lead Terry Baniel then applied a custom wig.

Romulan makeups included prosthetic ears to create an angular crescent-moon shape, and a smooth swept-back forehead appliance that extended to the center of the cranium. “J.J. did not want to see any hair lace in the wig applications,” noted Harlow, “so we made the entire forehead and eyebrows as one piece, with hair punched into the silicone before application. I wanted to give the Romulans an



A robotic police officer on a flying motorcycle attempts to apprehend young Kirk in his Corvette. The production built the hoverbike around the framework of a dirt bike. The special effects team articulated the prop on a parallelogram rig that extended from an Allan Padelford camera car and connected to a mini-gimbal inside the body of the bike. As the stunt department towed the Corvette, the hoverbike performed swooping motions, with pitch, yaw and roll, alongside the moving vehicle.



animal look, so we widened their nose bridge and did some interesting stuff with their brows — but nothing so extreme that you couldn't believe they were real. Neville Page then came up with some fantastic tattoo designs that Tinsley Transfers created and we applied."

Digital Domain transformed the police officer's face into a digitally rendered robotic mask, animated with mouthpiece vibration and a camera eye.

Harlow's team generated makeups for 40 Romulan characters including custom prosthetics for Nero, who bears scars of experiences in a Klingon prison camp scene that was excised from the film. "One of his ear-tips was gone," said Harlow, "and he had a scar that went from the back of his head to the front. Then we gave him and all of the Romulans a Prosaide bondo transfer representing a branding on their arm that was put there by the Klingons. It was like a stardate, in Klingon, that signified the crew of the Narada had all been through this same experience."

Romulans first appear when the Narada attacks a single-engine Federation starship, the USS Kelvin. "The Kelvin had a very run-down, old submarine feel to it," commented Alex Jaeger. "Scott Chambliss designed the interior sets to have a claustrophobic feel, with a lot of handrails and fittings. We aged the exterior with streaks of grease and rust."



Years later, Kirk -- still pursuing an aimless life -- pauses to contemplate his destiny represented by the form of the USS Enterprise under construction at a Federation shipyard. The production filmed the scene at an electrical power plant in rural California. ILM used the power station's smoke stacks, gantries, pipes and cables as a framework for the vastly larger structure. Digital paint and rotoscope artists manipulated live-action footage, while the digimatte department added the skeletal Enterprise. Compositing artists layered elements with atmospheric lighting effects to final the shots.

The opening shot of the Kelvin involved a dramatic, 40-second camera move not planned in initial previz. "David Dozoretz and his team did extensive previz in the early stages of the production," stated ILM animation supervisor Paul Kavanagh, "creating very exciting animatics. But when J.J. and his editors started cutting live-action and previz together, they decided they wanted to tell a different story in quite a few sequences. So we did something we don't normally do at ILM — we started creating our own previz."

ILM orchestrated the Kelvin reveal during principal photography at Paramount, working in a tented area where Abrams reviewed shot design. "J.J. wanted to create a sense of mystery in the shot," remarked Kavanagh. "We started with the camera on the edge of the Kelvin's main saucer, very close so we didn't know exactly what we were looking at. As we came around the dish, we passed on the dark side so the interior-lit windows streamed past, creating beautiful lens flare effects. The camera came up over the lip of the saucer, upside-down and rolling until it flew up to the central dome and bridge. It was very close, so it was just all shapes at that point. And then the camera pulled back, revealing the big engine nacelle, then kept pulling back to reveal the Kelvin, completing a 720-degree roll. Each piece of the shot revealed a little bit more of the story, keeping the audience intrigued until the end, when we finally revealed this starship."

The Kelvin faces off with the Romulans, who mercilessly open fire on the vessel causing crewmembers — including first officer George Kirk (Chris Hemsworth) and his pregnant wife (Jennifer Morrison) — to abandon ship. The filmmakers revised the sequence considerably in

postproduction. “In the revised scene,” recalled Kavanagh, “J.J. decided it would be more dramatic if Kirk defended the escaping shuttles by taking the Kelvin on a suicide run into the Narada. That was not part of the original cut; so they inserted black cards with shot descriptions where they had no previz. Roger and I then went down to Paramount with a laptop loaded with Maya and all our assets, met with J.J. and his editors, and discussed the kinds of shots he might want to see.”

Back at ILM, Guyett and Kavanagh assembled a rapid-fire previz team of animators and layout artists. “We chose animators who had knowledge of camera work,” explained Kavanagh, “so we could get a fast turnaround working on a user-friendly camera rig inside Maya. We would spend maybe half a day roughing out a shot, and then move on to the next one.”

ILM developed animation tools to replicate the style of photography on set. “We noticed J.J. liked handheld camera shake effects,” said Kavanagh. “He would sit behind the camera and rhythmically tap his hand on the back of the film magazine. When we cut our exteriors with that live-action, we felt that we should try to emulate what J.J. was doing on set, so we came up with some techniques to do that.” After setting up keyframe animation, animators applied camera shake via a small rotational motion capture sensor on a tripod at their workstations. “We hooked the sensor up to the CG camera on our animation inside Zeno. As we tapped our desk in the same way that J.J. had tapped on his camera magazine, the motion sensor on the tripod picked up the vibration and translated that motion to our smooth camera moves.”

“One of the things that I have always been very conscious of,” remarked J.J. Abrams, “was having visual effects shots feel as if they were being filmed by a live camera operator, not by a perfect prescient computer. That’s a really important element to the work that Roger and ILM did. They elevated scenes by incorporating our shooting style into really cool shots that blended perfectly with the live-action. It was very exciting to see them incorporate the look of the movie into the visual effects.”

The Kelvin conflict included the appearance of the Narada through a black hole — a cosmic singularity not directly observable by any known optical science. “The nature of a black hole precludes any light and visual spectacle,” admitted Abrams, “but we felt we could take liberties given that the creation of our black hole is not a natural occurrence. I remembered the work that ILM did years ago on *Twister*, which at the time was incredibly groundbreaking, and the scale of those storm funnels was pretty frightening. I thought we could use similar style effects to define the borders of the black hole, to create a sense of scope and dramatic impact, as opposed to just sheer darkness.”



Kirk’s womanizing nature gets the better of him in an Iowa bar populated by alien creatures and a contingent of Starfleet cadets, including the formidable xenolinguistics specialist Uhura (Zoë Saldana). Makeup department head Mindy Hall and Proteus FX supplied three dozen species of alien creatures peppered through the film, many of which were exotic lifeforms new to the franchise. For the barroom scene, Proteus FX makeup effects supervisor Barney Burman created an ogre-like alien barfly (Douglas Tait) using a multi-piece prosthetic makeup with oversized ears and hands.



Burman works on prototype clay sculptures of Zachary Quinto as Spock and Leonard Nimoy as Spock's elder time-traveling self.



Burman divided duties with makeup effectsco-supervisor Joel Harlow, who undertook further designs, mass-production and execution of Vulcan and Romulan makeups on set. Prosthetic makeup artist David Dupuis and Harlow apply seamless encapsulated silicone gel appliances to the upper portions of Nimoy's ears.



Protease handled makeups for a statuesque Enterprise crewmember known as 'Madeline' (Kimberly Arland). Madeline makeups included silicone appliances tinted with bronze metallic powders, chrome silver corneal contact lenses and needle-toothed prosthetic dentures.

ILM began black hole tests as two-dimensional art that resembled a nebula, with light and matter pulled through a gravitational well. “It was hard to explain the concept in stills,” said Alex Jaeger, “so I took the images into Adobe After Effects and created animation timings. Once we got a general idea, we rendered elements and took them into our Saber rapid compositing department to further develop the look. J.J. fell in love with a Saber test that had very fast bright flashes and camera shake. That helped define the ‘animal’ nature of the effect.”



Among the 40 Romulan characters created by Joel Harlow Designs was Nero (Eric Bana), vengeful captain of the Narada. Nero's makeup consisted of silicone full-ear prosthetics, a smooth swept-back forehead appliance that extended to the center of the cranium, and tattoo transfers applied after prosthetic application.

To create 3D depth in black hole simulations, ILM applied fluid dynamic technology. “Sequence supervisor Jeff Grebe started to play around with rendering curves,” said ILM CG supervisor Joakim Arnesson. “He built a node tree that allowed us to render particles as either points or curves, and then we could preview those effects in an interactive graphics library on screen, before committing to a render. That was one of the key technologies that we developed for the show.” The simulation team experimented with refraction and curve motion to define phenomena at the heart of the black hole. “It was essentially a particle simulation; but once we generated a particle, we tracked it over time and drew a curve between the points. At render time, we then decided if we wanted to make the curve more squiggly or put a smoother motion on it.”

Grebe’s team rendered multiple layers of particles and streaking elements in a three-dimensional vortex that spun faster toward the center and transitioned from light to dark, with green and blue coloration. Saber artists Dan O’Brien, Alex Tropiec, Grady Cofer and Chad Taylor then manipulated the rendered elements with distortion effects and layers of cloud-like particles.

The black hole effect was complicated in shots requiring the anomaly to be seen from both sides. “We wanted to create an interesting dimensionality in this effect,” said Roger Guyett, “so we gave it an odd twist. When you see it front-on, it had all the characteristics of a three-dimensional object. When the camera traveled past it, we revealed it was actually a flat two-dimensional plane.” ILM generated the effect using two 3D maelstrom simulations, rendered back to back, with intersecting vortices. Compositors and Saber artists then used depth hazing, mattes and sweetening effects on top of rendered elements to integrate vessels crossing the event horizon, creating the impression that solid objects were appearing from another dimension.

The Narada appears from the black hole as a forest of jutting metal spikes. Based on a design by concept artist James Clyne, the ship's configuration was envisioned as a side effect of inter-dimensional travel. "The idea was that the Narada had started out as a simpler design," explained Alex Jaeger. "Time travel had caused a mutation, which grew over the years, creating a mix of hard surfaces and organic shapes made of metal." Bruce Holcomb's modelmaking team built the Narada as a geometric shape and layered sweeping prongs onto the core until it resembled the randomness of the concept art. "The main body of the ship was toward the back, so the spires formed a tunnel in front, which made for some cool, creepy shots as the camera flew into this cocoon of organic shapes." On Paramount's largest soundstage, Scott Chambliss and senior art director Keith Cunningham built modular Narada interior sets that could be reconfigured to suggest different areas of the ship.

Nero opens fire on the Kelvin using barbed projectiles that separate like cluster bombs and rip through the starship's hull. The production simulated explosions on set. "We had an explosion in the medical bay that was practical," said physical effects supervisor Burt Dalton, "with stunt guys being jerked aside and a big collapsing set piece. In the hallway, where a wall is ruptured and a woman is sucked out, we blew out the side of the set practically. We had a stuntwoman on an overhead trolley, and air movers simulated suction as we pulled her out of the hole." ILM continued the stunt with a handoff to a digital double as the crewmember flew into the vacuum of space.

ILM generated exterior explosions as entirely digital zero-gravity detonations. "When a ship exploded," commented Roger Guyett, "we wanted it to have real space physics. More often than not in a space movie, explosions appear very terrestrial. But the burn rate in space is very different from on earth, and objects would not explode in the same way. We wanted to make effects more appropriate to the environment."

Digital artist Raul Essig led development of zero-gravity explosions using volumetric particle effects. "The tricky part with an explosion in zero-g," observed Joakim Arnesson, "is that, in theory, because there is no atmosphere to slow down the particles, everything should expand radially. That doesn't



At a Starfleet Academy hearing, Kirk answers charges of insubordination in a starship training exercise and exchanges sharp words with Spock. The production selected the Long Beach city council chamber to represent the Starfleet assembly hall, and dressed the set with greenscreen backing in areas destined for digital enhancement. Tracking markers served as registration points to assist Svengali FX artists in integrating digital set extensions as the camera moved about.



Svengali visual effects supervisor Stefano Trivelli conferred with Roger Guyett and J.J. Abrams to determine the extent of digital environment extensions in the Starfleet council and determined that the scene would best be served by adding an additional tier of seating filled with several hundred more cadets. To fill seats, extras dressed in Starfleet uniforms sat in small groups against black velvet while three cameras filmed their reactions. Svengali then replaced upper portions of the production plates with a 3D upper tier and tracked audience members into seats.

make it fun or structurally interesting, though, particularly if we are hitting a ship in 20 different places. So we had to be creative in deciding what the explosions should do. In the end, we applied noise breakup on the distribution of particles to control how the explosions spread out. We used our new volumetric shaders in particle simulations, which broke up when they collided with geometry. Each explosion involved several render passes: fire, smoke and smaller debris. There were also spark particle simulations; and for closeup explosions, our creature development team did rigid body simulations.”

George Kirk’s final act of heroism, ramming the Kelvin into the Narada, involved digital fireball effects and a physical effects rig on the Kelvin set. “We put the captain’s chair on a slide,” Burt Dalton elaborated. “Chris Hemsworth sat in the chair, we slid him forward through the set, and J.J. captured pieces of the performance. When they put those pieces together in post, it looked as if Kirk was being slammed toward the front of the ship.”

Kirk’s wife escapes Nero’s attack to raise her son in rural Iowa. Abrams filmed Iowa scenes around Bakersfield, California. ILM and Digital Domain contributed digimatte elements to the Iowa scenes in which a preteen Jim Kirk (Jimmy Bennett) joyrides in a Corvette and attracts the attention of a robotic police officer on a flying motorcycle. Compositors replaced California mountains with flat horizons and added 3D shapes representing large distant industrial structures reminiscent of Syd Mead art.

Production realized the hoverbike as a full-scale prop built around the framework of a dirt bike that fit inside a dummy chassis. Physical effects used a mobile rig to create the illusion of the bike and rider coasting above the road. “We built a parallelogram with a mini-gimbal on top,” commented Burt Dalton. “We used an Allan Padelford camera car, which was a very low-profile vehicle with a big flatbed between the wheels and the driver. We mounted the parallelogram to that and could lower the arm down to about three feet off the ground or raise it up to 13 feet, while the bike stayed level. We engineered the rig to ten times safety requirements, because we had to maintain stability if we ran off road. At one point, we got it up to nearly 60 miles per hour.”

An x/y gimbal at the hoverbike’s center of gravity allowed the prop to pitch and roll, while a 90-degree yaw plate allowed the parallelogram to slide in and out from the camera vehicle. Working with stunt coordinator Joey Box, a stuntman rode the hoverbike with a safety cable securing him to the seat. Effects technicians used Kuper motion control to program a flight path, and then cued motions to the rider’s performance.

Digital Domain performed rig removals and ILM supplied a conceptual design to transform the officer’s face into a robotic mask. Digital Domain then modeled and tracked the mask to the actor. “We added the mechanical face,” said Digital Domain visual effects supervisor Kelly Port, “and we replaced the top of the head, which had originally contained a visor. In closeups, we added a slight vibration on the mouthpiece when he spoke, and a camera aperture in the eye that animated.” For wide



Responding to reports of the Narada’s threatening appearance above the planet Vulcan, Federation starship

angles of the bike swooping around camera, performing a U-turn in midair, ILM modeled and animated the entire bike and rider digitally.

Kirk evades the police officer by crashing through a fenced-off area. Burt Dalton's team rigged a pneumatic ratchet-pull on gates in the fence to allow the Corvette to crash through without wrecking. The car then skids to the brink of a quarry, and Young Kirk dives out as the vehicle sails over the edge. Dalton's team rigged a series of physical effects to enable the stunt to be captured in-camera on a flat open field.

Bennett performed the Corvette spin in a non-mobile vehicle, which effects technicians ratcheted from the rear. The actor then performed the leap from the car onto an off-camera crash pad. For a high angle of the car plummeting and Young Kirk clinging to the quarry edge, the production dug a 12-foot-deep, 30-foot-wide hole in the desert floor. The stunt department then used a drag rig to pull Bennett to the simulated precipice as the Corvette fell behind him. "Roger wanted the car to fall into a real hole instead of it being all digital," said Dalton. "We hung a car on a four-point cable gimbal from a crane. One cable went from the car's left rear to the front right, and another from the right rear to the front left. As we winched down on the left front, the right rear went up, like a big four-point marionette." The effects team swung the car out and over the precipice. ILM then composited a digimatte quarry, dust and atmospheric effects, and transitioned to a digital vehicle for the final part of the Corvette's descent.

Meanwhile, on the planet Vulcan, Young Spock (Jacob Kogan) struggles with his own youthful anxieties. The production filmed exterior Vulcan scenes at Vasquez Rocks in Agua Dulce, California, and shot stills and aerial plates of San Rafael Reef near Green River in Utah. ILM digimatte artist Yanick Dusseault used the photographic textures to create an establishing shot of soaring Vulcan city architecture based on Ryan Church conceptual designs. "Vulcan is a very arid, volcanic planet," Alex Jaeger remarked. "The locals built their cities in the shade of giant tilted tectonic plates — hanging buildings from above, as well as coming up from below. The practical sets adopted that idea as the cornerstone for Vulcan architecture, and we interpolated that into digital set extensions. The rule was 'no 90-degree angles.' Windows were diamond-shaped. Everything was slightly skewed."

Young Spock is seen inside a Vulcan learning center, a vast darkened chamber filled with bowl-like depressions containing holographic displays. The production built a partial set containing one full bowl and two partial bowls. ILM CG supervisor Nigel Sumner then oversaw the chamber extensions, adding hundreds more learning cells. "We shot elements of students to place inside the bowls," explained Roger Guyett. "We set up a video projector system on set to project into the main bowl, then we

crews are shuttled to a sprawling space station in earth orbit, where the fleet prepares to mount a rescue mission. ILM built the space station as a highly detailed digital model based on a design by production concept designer Ryan Church. Ancillary starships were designed to represent vessels of Kelvin vintage, with varied engine and hull configurations intended to distinguish them from the newly launched pride of the fleet, the USS Enterprise.



A shuttle approaches the NCC-1701 Enterprise. After an extensive design effort, Scott Chambliss' team arrived at a streamlined Enterprise that maintained classic elements of the original series starship, updated with more powerful engines and new mechanical functions. Added details included a transparent dome above the bridge, which ILM

animated more layers of video images surrounding each student.”

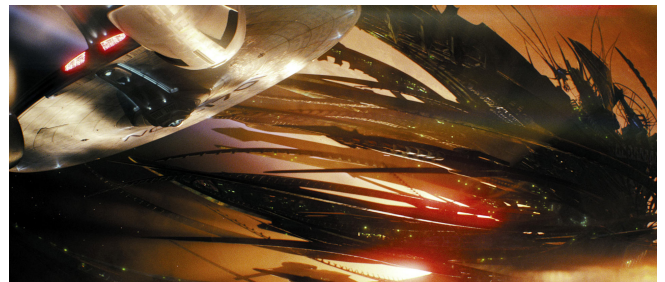
Other Vulcan environments included a Science Academy council, filmed in SkyRose Chapel in Whittier, California, to which Svengali Visual Effects added Vulcan window views and giant statuary inside a Vulcan temple. “The temple was pretty much just a floor on a big greenscreen stage,” said Guyett. “ILM added all the walls and statues as digital set extensions.”

modeled with structures beneath suggesting sensor arrays and radar dishes. Viewpaint artists textured the hull surfaces with interference paint schemes that reflected light in a manner similar to the practical model used in the first Star Trek feature.

Back on earth, Kirk in his mid-20s (Chris Pine) has become a reckless young man prone to bar fights. A bar room scene featured aliens including an ogre-like barfly known as ‘Brian’ (Douglas Tait). “‘Brian’ was one of our generic character code names,” related Barney Burman, “but he was my baby. He was a multi-piece makeup that I sculpted over a lifecast of the actor, elongating the face and moving the mouth below the actor’s chin. We cast all of the pieces in silicone and gave him oversized hands, which helped the scale. A key part of the character was the size of his ears. Initially his ears were human-size, and it just looked like an appliance. Once I enlarged the ears, it balanced everything, made his head look long and his eyes close together. He wasn’t mechanized in any way — the actor drove all the motion in the face.”

Stern words from Starfleet Captain Christopher Pike (Bruce Greenwood) leads Kirk to drive his motorcycle to a neighboring shipyard where he ponders a massive starship, the USS Enterprise, under construction. J.J. Abrams filmed the scene at Pastoria Energy Facility Power Plant in Lebec, south of Bakersfield. “Our aerial director of photography, David Nowell, shot aerial plates of the power station,” said Roger Guyett. “We used parts of the practical gantries, pipes and cables as the framework for the larger structure.” Digital paint and rotoscoping lead Beth D’Amato oversaw manipulation of live-action footage, including enhancement of Kirk’s motorcycle — a practical working prop from which ILM eliminated wheel forks. Digimatte added the deconstructed Enterprise above power station architecture, and sequence supervisor Todd Vaziri composited elements.

Kirk enlists in Starfleet and travels to San Francisco, a towering metropolis rebuilt since a mid-21st century cataclysm. The production shot aerial plates of San Francisco, which ILM heavily modified. As in previous Trek films, San Francisco’s Transamerica building was featured as a point of reference among the monolithic future structures. The Golden Gate Bridge contained no futuristic adornments, and was integrated into plates intact, projected onto 2D cards. Angles of the city consisted predominantly of 3D structures layered through levels of haze to create parallax effects. The production also shot ground-level location work on the campus of California State University Northridge, in Los



The Enterprise emerges from warp drive to find the Narada poised above Vulcan amidst a debris field comprised of Federation starships it has summarily destroyed. The ILM modeling team created wreckage articulated to drift through frame as the Enterprise maneuvered to avoid collision. Animators covered the scene in graceful and vertiginous camera moves, including a shot that rotated nearly 180 degrees to reveal the Enterprise confronting the Romulan aggressor. The ILM digimatte department enhanced the drama of the scene

Angeles. “We added the Golden Gate Bridge in the background,” said Eddie Pasquarello, “and expanded the city from another angle. Some of our aerial shots of San Francisco began with a real plate; but by the time we were done, it was pretty much all 3D digimatte, with the exception of the bay.”

with a red nebula backdrop, which compositors layered with backlit volumetric lighting effects and clouds of debris and particulate matter.

Inside Starfleet, Kirk proves his mettle in a star-ship simulator exercise familiar to Trek aficionados as the Kobyashi Maru scenario — an un-winnable standoff between a stranded freighter and Klingon aggressors. “The Kobyashi Maru was a Ryan Church design,” explained Alex Jaeger. “It resembled the Excelsior, but was more of a cargo version. We made the ships look photoreal, based on the theory that if videogames are as sophisticated as they are today, a Starfleet simulation would look more so.” The simulator sequence also featured Klingon *Birds of Prey* and a D7-class Klingon battle cruiser, both given a detailed refit.

Svengali visual effects supervisor and lead compositor Stefano Trivelli oversaw monitor composites for the flight simulator and furnished digital environment extensions for a scene in Starfleet’s council chamber, expanding a gathering of Academy personnel thrown into disarray when news arrives of the Narada’s appearance above the planet Vulcan.

In response to the incursion, shuttlecraft take flight from a Starfleet hangar, deploying crewmembers to orbiting starships. Abrams filmed the hangar scenes in a Marine Corps Air Station blimp hangar in Tustin, south of Los Angeles. “The hangar scene was one of our most complicated compositing challenges,” stated Roger Guyett. “We had 20 or 30 CG shuttles taking off and hundreds of extras running around. It was a lot of layers and elements.”

Special effects supplied interactive mechanical effects with full-scale shuttlecraft props. “We built a lot of practical mechanical shuttlecraft doors,” Burt Dalton related. “We had clamshell doors, hatch doors and RTD-bus-style doors that opened from the center out. They were all hydraulic and/or Kuper controlled so they would function in wide master shots, with no faking it.” Trek veteran John Eaves generated modular, interchangeable shuttle designs. “There were three shuttlecraft props configured in a number of variations. They all had practical rigs inside, including a mechanical ramp that hydraulically extended and retracted. We used liquid nitrogen, liquid CO2 and steam to make them come alive, and wind machines to simulate down-drafts from propulsion units.” ILM added flying vehicles, environment extensions and a digitally replicated crowd.

Shuttlecrafts convene on a large space station in earth orbit, where starships are being readied to engage the Narada. Bruce Holcomb created a

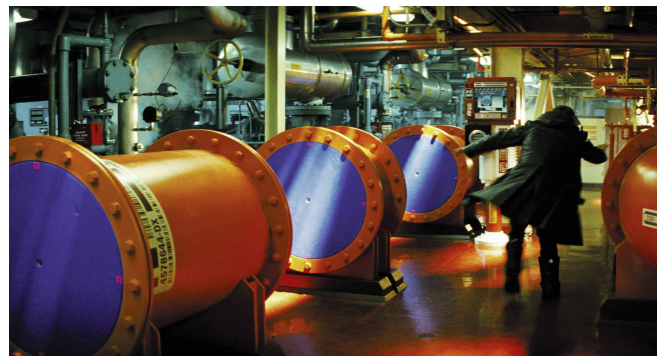


The Narada extends a mechanical tether into Vulcan’s upper atmosphere, fires plasma energy towards the planet surface, and then injects a highly volatile material that causes planetary implosion. The production built the Narada drill platform as a partial set, a vertical column supporting a one-third slice of circular platform, filmed in the parking lot at Los Angeles’ Dodger Stadium. The stunt department used a descender rig to film Enterprise crewmembers parachuting to the platform. ILM composited characters into synthetic environments, with simulated shadows and vapor whipping past, and used digital doubles for wider shots of hurtling bodies.

detailed model of the space station based on a Ryan Church design. Alex Jaeger designed six additional ships to represent ancillary Federation starships of Kelvin vintage. Kirk and medical officer Dr. Leonard ‘Bones’ McCoy (Karl Urban) then see the newest vessel, the Enterprise, finally complete in orbit.

Abrams staged Kirk’s first glimpse of the pristine Enterprise as a dramatic reveal. “The shot began at a shuttlecraft window,” related Paul Kavanagh, “with Kirk and Bones looking out towards the Enterprise, the camera keeping on them to catch the reaction on their faces. As the shuttle passes by camera, we pan with it under the nacelle of another starship. Then we reveal the Enterprise herself in a heroic silhouette — three-quarters on, looking up — which was always J.J.’s favorite angle.” The final framing also emphasized the ship’s scale. “J.J. wanted the edge of the saucer section to break frame to the left, and the edge of the nacelle to break frame right. Keeping the ship partially obscured made her feel even more huge.”

The starship’s gleaming surface posed a challenge to maintaining scale. “Perfection tends to be the curse of computer graphics,” observed ILM co-visual effects supervisor Russell Earl. “We couldn’t weather down the Enterprise to take the ‘curse’ off the CG, because this was a brand-new ship; but we gave her enough detail to create scale.” Modeling and texture teams studied reference of cruise ships, submarines and naval vessels. “We noticed that vehicles of massive size had a lot of surface imperfections, with ripples in their paneling where surfaces didn’t come together perfectly. We created some of that detail in our model. A lot of that we created in textures — specular maps and reflection maps — and the shaders.”



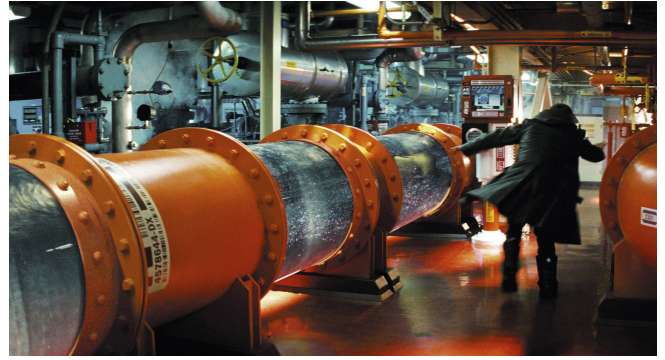
After a sojourn on a frozen Federation outpost, Kirk and Starfleet engineer Montgomery Scott (Simon Pegg) beam onto the Enterprise – but a slight miscalculation lands ‘Scotty’ in a fluid-filled conduit in the ship’s engine room. The production filmed engine room scenes in a Budweiser brewery, dressed with dummy tubes.

Engaging warp drive, the Enterprise enters a tunnel of light, which ILM created using combinations of particle effects and streaking image treatments. “It was as if the ship was in a tube of warp energy,” commented Eddie Pasquarello. “Tom Fejes’ team rendered particles; Conny Fauser then created the overall look from streaking effects generated in Saber. For warp-speed views seen out of the Enterprise main viewer, we again created effects in Saber, and handed those off to compositing.”

Dropping out of warp, the Enterprise encounters a field of debris comprised of Federation starship wreckage. Russell Earl and sequence supervisor Greg Salter oversaw creation of the debris field as a vast array of drifting wrecks. “We layered the scene with very fine particulate material,” stated Pasquarello. “That allowed us to illuminate shards of light with volumetric effects as the Enterprise passed through the debris field. And then we revealed the Narada sitting there above Vulcan.”

The Narada extends a giant drill toward the planet, preparing to unleash a force of ominous destructive power. “The drill was originally part of the ship’s mining equipment,” said Roger Guyett. “They extrude an extremely long tether into the planet’s atmosphere to about 10,000 feet, and then fire down to take a core sample. The Romulans then use a red, viscous fluid that is so unstable it can create a black hole and destroy the planet.” ILM generated the volatile ‘red matter’ as a fluid simulation, animated to react to touch. The material is housed inside a captured Vulcan spaceship in the Narada hold. Bruce Holcomb’s team modeled the spaceship based on a Ryan Church rendering of a fanciful, 80-foot-long vessel with a rounded forward fuselage and rotating elements trailing in back.

Wearing pressure suits, Kirk, Lieutenant Hikaru Sulu (John Cho) and chief engineer Olsen (Greg Ellis) skydive to the drill platform on a sabotage mission. Roger Guyett directed the space jump as a second unit sequence in the parking lot at Los Angeles’



Digital Domain completed the environment by digitally generating transparent tube sections in between opaque connecting pipes, and inserted bluescreen elements of Pegg being pulled through a pool of water. Wider angles of Scotty surging toward a ceiling-mounted turbine used a digital double built from photographs of the actor.



Introduced with Scotty on the remote Federation outpost of Delta Vega is a small alien, Keenser (Deep Roy), which Proteus created as a full-head silicone makeup designed for digital enhancement.



Dodger Stadium. “We needed an elevated piece of land that gave us a clear horizon,” Guyett explained. “We filmed two scenes there, both in natural sunlight. One was the drill platform, the other was an ice planet where Kirk is marooned later in the film.”

The drill platform set consisted of a vertical column supporting a one-third slice of circular platform approximately 60 feet in diameter, surrounded by greenscreen. To film characters diving to the platform, the stunt department rigged a 100-foot descender rig. The special effects department surrounded the actors with wind machines to simulate high altitude winds, vented helmets with aeration rigs to keep face masks from steaming up, and staged parachute deployments using a combination of wind machines and cable rigs.

ILM composited characters into synthetic environments — with Saber effects of reflections mapped onto faceplates — and used digital doubles for wider shots of hurtling bodies. “What sold the sense of travel,” observed Russell Earl, “was the ‘picket fence’ effect: light and shadow whipped past the characters, as if they were moving very quickly through shadows cast by protruding parts of the drill. Then we added clouds of vapor moving quickly through frame to sell the sense of danger and high wind.” Sequence supervisor François Lambert oversaw approximately 200 visual effects shots in the sequence, which included drill platform extensions, a full 360-degree environment of the drill shaft extending up to the Narada and down to the Vulcan planet surface, cloth simulation parachutes, fluid simulations of plasma energy jetting from the platform, and a city far below.

As red matter initiates seismic tremors on Vulcan, Spock beams down to rescue members of the Vulcan High Command, including his parents (Ben Cross and Winona Ryder). The transporter effect was a departure from previous incarnations, although in theory it adhered to the original premise. “J.J. described the effect as transporting particles of not only the person,” explained Earl, “but also the immediate space around them. As particles formed, they generated light and became visible, spinning in space. This built to a flash, and then the person disappeared.” ILM strove to bring a photographic realism to the concept. “We focused on the idea of the space around the person starting to activate, encircling the subject as particles were sucked away and reconstituted elsewhere. To achieve that, we built matchmove proxy geometry of characters, and then ran a 3D particle simulation, slowly building up the number of particles, which produced trails of light. Then

To lend the character a more alien appearance, Digital Domain removed the actor’s eyes, blended a dark cavity into the eye sockets and added antenna-like rods that could dart about. Animation required a separate track of the actor’s head and eyes to root the rods to the back of the eye socket and gauge their orientation and reaction to other characters in the scene.



Starfleet personnel react in horror as the Narada drills down into San Francisco Bay, preparing to demolish earth. The production photographed Starfleet exteriors on the campus of California State University Northridge, near Los Angeles, and filmed aerial plates and scenic reference in San Francisco. ILM heavily modified the city to include towering structures erected to replace those lost in a mid-21st-century cataclysm. Maintaining continuity with previous Star Trek films, digimatte artists retained San Francisco’s Transamerica Building as a point of reference. Angles of the city consisted predominantly of 3D structures layered through levels of haze to create parallax effects.

we did warping in the composite, and did Saber work with particle passes and interactive light passes to simulate a three-dimensional effect.”

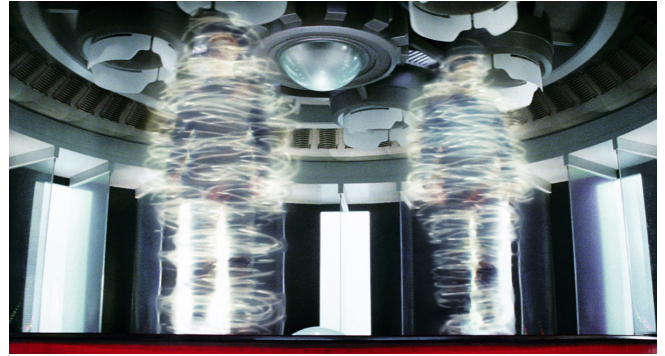
Spock arrives amid an earthquake, which Burt Dalton’s team evoked on set using falling dust, wind machines and weighted dummy rolling boulders. ILM then multiplied falling rocks and digitally tore the landscape to shreds. “Spock and the elders see a wave of destruction traveling towards them,” related Earl. “We didn’t shoot any practical elements for that because of the massive scale and the amount of interaction with the geometry of the planet. We modeled half a dozen varieties of peaks, mixed and matched those into a 3D matte painting, and worked with our digimatte and simulation departments to create a combination of sims and re-projected paint effects.”

Digital model and simulation supervisor Karin Cooper oversaw rigid body simulations while Joakim Arnesson and Frank Losasso Petterson shattered

Vulcan landscapes using digital fracture technology. “We applied Voronoi noise effects,” Arnesson explained. “Those are like cell patterns that create stress points through solid geometry as procedural effects. We controlled the way rocks broke apart using stress fields to influence the shapes and sizes of the fractures.” Digital artist Aron Bonar created flows of molten magma using fluid dynamic splash effects. “We generated different colors and dynamics to represent huge viscous lava plumes, and rendered those as blobs or spheres depending on their proximity to camera. On top of that, we created smoke simulations using our volume particle shader.”

Spock beams away from Vulcan with a handful of survivors when, seen from space, the planet collapses into a black hole. Alex Jaeger created a series of still images to previsualize the planetary implosion using a NASA photograph of Mars. Digital modeler Greg Killmaster generated the main simulation of the planet fracture; technical director David Weitzberg led particle simulations; and Ben O’Brien oversaw compositing and Saber effects. “The creature development team handled rigid body simulations,” related Arnesson. “They started with a sphere, fractured it into distinct pieces, and worked on it by hand to randomize the breakup. Then we added another rigid sim and our fracture pipeline, creating emission points where the larger sim broke apart, and used that to add secondary sims of finer particles.”

Subsiding continents, glowing magma fractures, roiling clouds and glimmers of the planet’s core collapse into a void. “We wanted to create a feeling of massive planetary scale,” explained Russell Earl. “The black hole ate up the planet from its center, leaving just distorted space behind — pure black with stars warped around it.”



From the Enterprise transporter room, Kirk and Spock beam onto the Narada. Roger Guyett studied the wide range of transporter effects created for previous Star Trek films and television series. ILM then departed from earlier versions, but adhered to the core premise of objects transporting as particles. Digital artists used 3D particle simulations to generate points of light spinning in space, creating trails of light around matchmove geometry of the characters. Compositors blended the effects with warping and interactive light passes.

Kirk and Spock manage to escape the planet's destruction, but an altercation on board the Enterprise causes Kirk to be jettisoned in an escape pod to an arctic Federation outpost on Delta Vega. As second unit director, Roger Guyett filmed part of the sequence on the ice planet set at Dodger Stadium, which the production constructed as a 60-by-80-foot arrangement of slopes and ice formations. Director of photography Daniel Mindel positioned a large silk over the set to create a diffuse light effect, with a bluescreen backing. Effects specialists Snow Business pumped in biodegradable paper-based snow, which Burt Dalton's team whipped to blizzard conditions using wind machines. Wide shots of Kirk as a tiny figure in the snow featured a child double to enhance the set's scale, surrounded by ILM digimatte enhancements.

Ferocious creatures attack Kirk, the first of which — a 'polarilla' — was based on a Neville Page design. ILM digital artist Damian Steel handled creature look development, while the animation team developed creature stance and gait. "Neville's drawings had the polarilla up on its knuckles like a gorilla," said Paul Kavanagh. "We felt that because the creature was running on snow and ice it would more likely open its paws flat, otherwise it would slip and fall. We tried making the creature's front end have a gorilla's topology, with its hindquarters like a polar bear, and we animated a couple of tests. In the end we mixed the two, so its front legs were like a polar bear, the rear-half like a gorilla."

Kirk next encounters a giant red-skinned sea creature that erupts through the ice. "Big Red was fun," said Kavanagh. "He had huge jaws that spread back in four sections, two little arms at the front like a T-rex, and a hundred eyes on the back of his neck. We wanted him to be quite threatening, so we kept his movements very fast and fierce."

For Big Red's explosion through the ice, Burt Dalton's team created large-scale interactions on set using latex-covered sections of white foam, which air mortars loaded with foam chunks blasted from below. Dalton's team also rigged an ice cliff to collapse under Big Red's weight, using a ledge of foam blocks on top of a 60-foot-tall ridge, held in place by mechanical trips. ILM added digital breaking ice, sprays of snow and the tumbling creature. Lola Visual Effects assisted ILM with environment enhancements for Kirk's confrontation with the persistent creature inside an ice cave.



Beaming down into a gathering of Romulans, Kirk and Spock engage in a fierce gunfight before splitting up to rescue Captain Pike and thwart the ship's attack on earth. Scott Chambliss built the Narada interior on one of the largest stages at Paramount, using modular pieces that could be reconfigured to create different areas of the ship. ILM then added digital extensions to expand the interiors as Kirk battled with Nero, leaping between platforms.



In a cargo hold aboard the Narada, Spock finds and steals a Vulcan ship of advanced design, previously captured by Nero. The production built the interior and entry ramp of the Vulcan ship, which Burt Dalton's team mechanized with a motorized swiveling pilot's chair. ILM generated the exterior based on a Ryan Church rendering of a fanciful, 80-foot-long vessel with a rounded forward fuselage and rotating elements trailing in back. ILM articulated the craft with engine elements that spun on a central axis, and generated 3D environments of the Narada hold and biomechanical cargo bay doors.

Elder Spock fends off Big Red and explains his presence to Kirk in a mind meld — a telepathic exchange that reveals Nero's theft of red matter, and the Vulcan technology that inadvertently caused the destruction of Romulus and banished Spock to the past. "J.J. wanted to visually demonstrate Spock's story," said Roger Guyett, "so we created a sequence that showed how Spock was sucked into a black hole, sending him back in time." Digital artist Yusei Useugi created a series of digimatte environments for the meld. Digital artist Daniel Pearson and Ben O'Brien created 3D rendered elements for a supernova explosion, which included a high-speed journey through star fields and a glowing red nebula surrounding Vulcan. Simulation teams created dynamic effects that shattered and obliterated Romulus.

Spock and Kirk seek a way off Delta Vega via the nearby outpost. For wide shots of the two crossing a glacier, the production used stunt doubles filmed near Anchorage, Alaska. ILM then added digimatte ice tower extensions and outpost. Abrams shot outpost interiors inside a warehouse in Van Nuys, California, which the production dressed with hardware representing derelict spacecraft and a small alien fur-ball familiar to *Star Trek* devotees as a tribble, which resides in a cage as one of many oddities owned by Starfleet engineer Montgomery Scott (Simon Pegg).

Accompanying 'Scotty' is a small crustacean-faced alien, Keenser (Deep Roy), which Proteus created as a full-head silicone makeup designed for digital enhancement. "We removed the actors' eyes," explained Kelly Port, "created a dark cavity in the eye sockets and added antenna-like rods that could dart about. We tracked the actor's head and eyes separately, and then created a rig to align the tips of the rods with the actor's pupils. That gave us our first pass on the eye-line. Then we played with eye-stalk motion, adding little twitchy moments that resembled blinks."

Scotty beams himself and Kirk to the Enterprise engine room, but a miscalculation lands him inside a tube filled with inert reactant. Abrams filmed the scene inside the Budweiser brewery, which Scott Chambliss dressed with large clear plastic tubes and opaque connecting pipes. Roger Guyett's team shot high dynamic range images of the set, and bluescreen elements of Simon Pegg being pulled through a pool of water on set. Digital Domain digitally rebuilt all clear sections of the tubes using on-set tubes as reference, and used the bluescreen elements to create the illusion of Scotty surging through the pipes. "We built and extended the clear tubes connecting the solid pipe sections," said Kelly Port. "To create reflections in the tubes, we tiled together the HDRI stills, projected that photography back into the plate in 3D and ray-traced reflections and refractions." Compositors inserted underwater elements of Pegg, with CG bubble particle animation. Wider angles of Scotty surging vertically toward a ceiling-mounted turbine used a digital double built from photographs of Pegg and a 3D turbine tracked into the set. Kirk triggers a release mechanism, dumping Scotty from the pipes, which Joey Box's team staged with a stunt performer falling on a descender rig amid water dumped from an overhead tank.

The film's finale — in which Kirk takes command to rescue Pike, who has fallen captive, and stop the Romulans from attacking earth — was honed extensively in postproduction. The sequence began with the Enterprise warping into the atmosphere of Saturn's moon, Titan. ILM worked with planetary scientist Carolyn Porco to create digimatte representations of the ringed gas giant and its moon. "Carolyn had been head of NASA's Cassini-Huygens project," commented Roger Guyett, "so she was very familiar with that part of the solar system. She gave us a lot of insight into how processes might work and where things were located geographically. We then mapped, moved and reorganized real space imagery to suit our needs dramatically."



The Narada pursues the Vulcan ship through a black hole to where the Enterprise is waiting for a showdown. The filmmakers tackled the depiction of the black hole with a degree of dramatic license, emphasizing its dual narrative significance as a time portal and destructive force. ILM generated early 2D tests of light and matter being pulled through a gravitational well. Saberartists expanded the concepts by combining rendered elements with bright flashes and violent camera shakes. ILM then developed custom particle simulations and fluid dynamic technology to define a three-dimensional vortex of immense power.

A shot of the Enterprise rising from behind Titan created a dramatic — and unexpected — alignment of images. "When we were composing the shot," related Paul Kavanagh, "J.J. suddenly said: 'Look at what you've done. The way you've framed the Enterprise dish with Saturn's rings — you've just created the Star Trek logo!'"

Kirk and Spock beam onto the Romulan ship and engage in fierce combat. Digital Domain provided gunfire for the sequence, adding phaser bolts and smoke and spark effects. ILM expanded the interior Narada sets with digimatte extensions, creating vertiginous views into cavernous machinery, which characters leap across. The sequence included shots of Spock piloting the Vulcan ship to disable the Narada's drill, now poised above San Francisco Bay. ILM generated shots of the giant drill crashing into the bay using aerial plates shot above the Golden Gate Bridge, and digital artist Tim Fortenberry generated water splash simulations.

Spock then leads the Narada to a safe distance from earth, where a showdown occurs — the Enterprise defending the Vulcan ship as it dives into the Romulan ship's maw, detonating red matter and creating a black hole. CG supervisor Hilmar Koch and sequence supervisor Leandro Estebecorena oversaw the depiction of raging cosmic forces, which tear apart the Romulan vessel. ILM combined full rigid body, particle and fireball simulations and special model builds to tear the ship apart. "Creature supervisor James Tooley oversaw a lot of the Narada breakup and destruction," noted Russell Earl. "That included shots inside the ship, and shots of the main door mechanisms being destroyed. The scale was so great, it was less of a pyrotechnic effect, and more like taking two massive skyscrapers and smashing them together into a black hole."

The black hole engulfs the Narada and threatens the Enterprise as its gravitational pull increases. Kirk responds by jettisoning the Enterprise warp core, causing the black hole to explode in a huge blue fireball that catapults them to safety. “It was essentially a big bang,” remarked Joakim Arnesson. “We created the fireball as a simulation of particles that expanded from the center of the black hole. On top of that, we applied volumetric shaders similar to our spaceship explosions. Each particle generated a volume, and we controlled the radius of the particles and how they blobbed together. And then we used a radial field to control the surface level. Olivier Maury in our software team helped develop those effects, and they became our next generation of volume shaders.”

The film concludes with Kirk’s promotion to captain and the Enterprise setting sail toward adventures — presumably, the adventures chronicled in the original television series. “The final shot going off into warp,” observed Roger Guyett, “was a little homage to the way they closed out the original TV episodes. We tried to match a style and color palette that could lead in to the old show. It was not overt, but it had a slightly retrospective quality to it.”

“It was everything great about *Star Trek* in one shot,” added Eddie Pasquarello. “It had beautiful digimatte work, beautiful lighting, and when the Enterprise went off into warp it created a wonderful lens flare effect. It was one of the most beautiful shots in the film.”

The nostalgic feeling percolated through the production, even for the previously uninitiated. “When I started the show two years ago,” recalled visual effects producer Shari Hanson, “I was excited to work with J.J. and Roger again after *Mission: Impossible III*, but I was only culturally aware of *Star Trek*. By the end of the production, I adored the story and the characters. But most of all, I appreciated why so many of our visual effects crew were lifelong fans. They truly loved this movie and this property, and it shows in their work on screen.”

With ILM visual effects producers Jill Brooks and Jeff Olson overseeing 250 artists handling 860 shots at ILM — and with more than 200 shots at Digital Domain, Svengali and Lola — passion for the project was widespread and elevated the film beyond simply #11 in a series. “It was a great honor to be involved with *Trek* history,” concluded Roger Guyett. “I watched the original series in the early 1970s when I was growing up in England, and I think this movie kept true to that spirit. Of course, the classic elements have all changed over various films, but we took inspiration from them and gave them a fresh look for this young and energetic crew. Ultimately, whether you are into *Star Trek* or not, J.J. made a very high-octane space adventure — and I’ve never had so much fun!”



The black hole consumes the Narada, then threatens to draw the Enterprise into its void. ILM generated effects of the black hole collapsing and exploding in a big-bang-style blast using simulations of particles expanding from the epicenter. The complexity and scale of the cosmic events required ILM to develop a new generation of volumetric shaders, which allowed artists to generate expansions of particles while influencing the radius of particles, the behavior of particles blobbed together, and the radial field of the explosion surface.

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Rage Against the Machines

ARTICLE BY JODY DUNCAN

At a presentation for invited members of the press  four months before his *Terminator Salvation* opened on thousands of movie screens around the world, director McG acknowledged, with good humor, what had been the general consensus of fans regarding the making of yet another *Terminator*: Surely, after 25 years and three mega-hit movies, the *Terminator* shammy had been wrung dry.

“Right from the beginning, we had two major strikes against us,” McG admitted. “One was, ‘We’re going to make *Terminator 4*’ — even though nobody was looking for a fourth *Terminator*. The second obstacle was: ‘Hey, I know! Let’s get the *Charlie’s Angels* guy to do it!’ The hardcore fans said: ‘That is the worst idea I’ve ever heard. This film is dead to me.’ We had to work very diligently to earn the trust of the public; and we did that by respecting — at every level — what Jim Cameron had created with *The Terminator*.”

Primary among fan concerns was that a fourth *Terminator* could be nothing but superfluous, as no narrative thread of the mythology had been left unexplored. Cameron himself had said that the story was over after *Terminator 2*. But at the press event, McG made a persuasive case that there was one critical aspect of the *Terminator* story that had not yet been developed. Though referred to in dialogue and in brief flashback imagery in the previous *Terminator* films, the post-Judgment Day, years-long war between the machines and human resistance fighters, and the rise of John Connor as the leader of that movement, had never been fully fleshed out. *Terminator Salvation* would tell that story.

McG shot the film at Albuquerque Studios and the New Mexico desert. By his side throughout production was visual effects supervisor and second unit director Charles Gibson, who assigned the bulk of the effects to Industrial Light & Magic, veteran of the second and third *Terminator* films, and Asylum. Rising Sun Pictures also made significant contributions. Special effects coordinator Michael Meinardus staged varied and large-scale on-set effects, augmented with miniatures by Kerner Optical. Finally, Stan Winston Studio — which had made its name with *The Terminator* in 1984 and had been a major player on both sequels — provided practical endoskeletons and other terminator effects.

In planning principal photography, McG and his team considered how they might give the movie a decidedly post-apocalyptic look. “I wanted the look of the film to be very realistic,” McG noted, “but ‘other.’ If we had a global thermonuclear war, what would that mean to the ozone and the color temperatures of the sky and landscapes? The sky would indeed be less blue, and there would be an ashen quality to the world. We went to great lengths to represent that idea. We used uncorrected lenses, which were more apt to flare and were not as sharp as traditional lenses. We also used three times as much silver in the processing of the film, treating our color stock almost as you would black-and-white. We added finishing touches in the digital intermediate, giving it a look designed to

make you cock your head to one side, and think, ‘Something is off in this world.’ And, of course, that ‘something’ is that the bombs blew it up.”

Terminator Salvation starts with a current-day prologue sequence in which convicted murderer Marcus Wright (Sam Worthington) awaits imminent execution in a death row cell. There, doctor and cancer victim Serena Kogan (Helena Bonham Carter) persuades Marcus to donate his corpse to Cyberdyne scientists for purposes that remain murky.

After a scene in which Marcus is put to death via lethal injection, the film cuts to the year 2018. The war with the machines is in full gear, and its ferocity is illustrated in an opening resistance attack on a Skynet communications facility. The sequence begins with a ‘missile-cam’ view of a post-nuclear landscape, a plate shot over the New Mexico desert by ILM visual effects supervisor Ben Snow and aerial director of photography David Nowell. “We shot that in Vista so that we could push in quite easily and add camera banking,” Snow explained. “That aerial plate blends into our digital matte painting of a Very Large Array — rows and rows of giant radio telescopes.”

The opening transitions to an ambitious all-in-one shot that begins with an aerial attack by resistance A-10 planes on the VLA dishes. The extended shot featured a combination of live-action elements, digital matte work, and Kerner Optical miniatures that were scaled replicas of the real VLA in New Mexico that consisted of rows of telecommunications dishes measuring about 80 feet in diameter and standing nearly 100 feet tall. “They are extremely complex metal structures, which we had to replicate at both 1/12 and 1/32 scale,” said Kerner Optical supervisor Nick D’Abo, who worked closely with Kerner creative director Brian Gernand and lead modelmaker Michael Lynch on the show. “For this first aerial attack shot, we built 12 of the 1/12-scale radar dishes out of soft alloy aluminum and fiberglass gel coat.” Director of miniature photography Martin Rosenberg shot the scaled set as special effects technician Geoff Heron collapsed hero dishes using both pyrotechnics and mechanical rigs. “The mechanical rigs pulled them down into the dirt, giving them a sense of real weight as they fell. They had been constructed to break apart at certain points, as well, and the soft aluminum gave us the look of twisted metal.”

The shot continues with helicopters transporting resistance troops arriving on scene. As it lands, the chopper bearing John Connor (Christian Bale) crushes a T-600 terminator, a precursor to the T-800 model that hunted Sarah Connor in *The Terminator*. “These early T-600 models have been alluded to in the previous movies,” said Charlie Gibson, “but we’ve never actually seen them. They are Skynet’s early attempt to blend in with humans — big, hulking terminators that never fooled anybody. We see them throughout the movie, sometimes as ILM-animated T-600s, sometimes as Stan Winston Studio creations. In this first shot, we flew in the Winston version on a wire and squibbed it.”

Stan Winston Studio and creature supervisor John Rosengrant had been inextricably connected to the *Terminator* franchise from the beginning, and McG had considered their involvement in his film to be crucial. “I didn’t want to just throw up a tennis ball on a C-stand and say, ‘Okay, that’s a T-600!’” said McG. “I wanted the actors actually interacting with Stan’s creations. So we built as much as we possibly could, taxing the studio to its absolute limits. There was an emotional element to it, too. Stan Winston Studio created the first terminator. They were an important part of this, and Stan’s presence colored every day of photography.” McG would, in fact, dedicate the film to the memory of Winston, who died while *Terminator Salvation* was in production.

To realize the T-600, Rosengrant and his team started with 2D concepts from production designer Martin Laing’s art department, and then essentially reverse-engineered the technology of the studio’s original T-800 endoskeleton. “We had to go back in time,” Rosengrant said, “figuring out what the T-600 would have been, based on what the T-800 was. McG summed it up in an interesting way: if you look at the evolution of computers, we used to have really big, clumsy monitors; and now we can slip an iPhone, which is basically a mini-computer, into our pockets. It was the same idea with the terminator. It started out big and clunky; and then the machines refined it into the Arnold model so that it could infiltrate the human world.”

The final T-600 design was bigger than the original endoskeleton — standing seven-foot-four — and had a more grimy, industrial finish than its shiny chrome predecessor. When that design had been approved, Winston artist Scott Patton sculpted the T-600 digitally, using XSI and Zbrush, and the crew launched into construction. “We only had about three months to create this thing,” Rosengrant recalled, “and so we rapid-prototyped the basic T-600 pieces; and then Dave Merritt and our model department sculpted all the little rivets, nuts and bolts by hand. We created molds of each of those master parts to create final pieces out of urethanes and fiberglass. It was labor-intensive because hundreds of parts had to come together. The endoskeleton matches human anatomy, and there are 206 bones in the human body; so it had all of those parts, plus a lot of other hoses and servos and mechanisms.”



Terminator Salvation, the fourth installment of the franchise launched in 1984 with James Cameron’s *The Terminator*, fleshes out the story of the post-Judgment Day war between Skynet-controlled machines and human resistance fighters – events referenced only briefly in the previous ‘*Terminator*’ movies. Director McG and visual effects supervisor Charles Gibson maintained continuity with Cameron’s original films by assigning the bulk of the visual effects shots to Industrial Light & Magic, veterans of *Terminator 2* and 3, and relying on Stan Winston Studio – designers of the original *Terminator* endoskeleton – for on-set, practical effects. In an early sequence, resistance helicopters attack a Skynet communications facility.

To give the final pieces the appearance of a metallic finish, the Winston team took advantage of new paint techniques it had developed for the high-gloss metallic suits in *Iron Man*. “For *Iron Man*,” said Rosengrant, “we had come up with ways of applying metallic finishes to urethane that gave us a really good look — trapping it in clear layers and things like that — and we did the same thing for the T-600. Then we did aging on top of that, matching the nasty-looking future that Martin Laing had come up with.” Richard Landon — another alum from the original *Terminator* — rigged the puppets with servos and machined joints operated through rods or radio control. A separate set of articulated or posable hands could be attached to the puppets, as needed. A puppeteering team from Stan Winston Studio that included Jason Mathews, Rob Ramsdell and Mike Manzel operated the T-600 pup-pet on set.

The shot ends with a figure emerging from the helicopter, firing into the head of the crushed terminator, and the camera panning up to reveal the face of John Connor. Assembled by compositing lead Pat Brennan, the 1,181-frame shot was one of ILM’s most challenging composites. “There were six plates that we had to get in and out of,” said compositing supervisor Jeff Sutherland. “We had the miniature element of the VLA dishes, desert plates shot in Albuquerque, plates of real helicopters mixed with CG helicopters, and real and CG A-10 planes. All the plates they’d shot for the various beats of action had to be stitched together very carefully, with transitions to get us from one to the next.” One of the inherent problems was matching lighting in plates that had been shot at different locations, at all different times of day. “We had to do a lot of cheats to make the lighting work. A lot of times we painted patches between plates, little stretches of landscape or sky to cover the transition from one to the next.”

Connor leads an attack on an underground bunker at the Skynet communications facility, realized in wide views via a digital matte painting by Jonathan Harb at Whiskytree. The second of McG’s extended



Stan Winston Studio supplied production with T-600 endoskeletons, precursors to the T-800 portrayed by Arnold Schwarzenegger in the earlier films. T-600 pieces were rapid-prototyped, then detailed with hand-sculpted rivets, nuts and bolts. Final urethane and fiberglass parts were assembled to create full-body and half-body puppets, operated via rods or radio control. Key artist Ken Cornett adjusts cylinders on the T-600 half-puppet.



Winston puppeteers operate the half-puppet for a scene in which the machine attacks a rising star of the resistance, John Connor (Christian Bale).



shots — this one lasting two minutes long — begins with Connor crawling out of the bunker to discover a departing Skynet transport ship filled with human prisoners. To chase after the transport, Connor takes control of an idling helicopter; but as he lifts off, a nuclear bomb explosion decimates the entire complex and forces the helicopter down. Connor emerges from the crash, only to be engaged in combat with the upper half of the crushed T-600. “Everything from the point at which Connor climbs out of the bunker to when he fights the T-600 was one long shot,” stated Charlie Gibson. “It was another complex shot with Kerner elements, digital matte painting, pyro, CG, and live-action of Christian Bale in a helicopter.”

On the studio backlot, Mike Meinardus mounted a helicopter shell on a gimbal against a blue wall for the shot of the craft’s lift-off — an imperfect bluescreen setup that required ILM to rotoscope the live chopper from the plate. As the helicopter rises, the camera flies around it, looking back toward the bunker. “In that shot,” said Ben Snow, “we’re looking down on a combination miniature/digimatte landscape, and then this atomic blast goes off, which was a practical explosion on the 1/32-scale set generated by the team at Kerner Optical.” After the shockwave takes out one of the satellite dishes, the camera tilts up on an all-digital view of the carnage, created by digital matte supervisor Giles Hancock, with 2D and digital dust and debris. The camera stays with the buffeted helicopter, and then dives into the chopper for a closeup of Connor’s face as he tries to regain control. “We started with the exterior bluescreen helicopter; and then we created a CG helicopter to blend that with a partial interior bluescreen helicopter buck. We push into that buck, and that’s where Christian Bale is sitting. So we’ve started with the exterior practical helicopter, gone digital for a second of the push-in, and then blended back into a practical element once we’re inside the helicopter.”

As Connor attempts to stabilize the helicopter, the aircraft spins around, hits one of the dishes, plows into the ground and rolls. The crashing, rolling helicopter was a practical element, shot on set,

Given the film's time is set in 2029, the visual effects team had to create a post-apocalyptic Los Angeles that reflected the future of the city. The team used a combination of practical and digital effects to create the ruins of the city. The team used a combination of practical and digital effects to create the ruins of the city. The team used a combination of practical and digital effects to create the ruins of the city.



Asylum also made major effects contributions, including digital environments for a sequence in which executed murderer Marcus Wright (Sam Worthington) stumbles into the ruins of Los Angeles, unsure of both his past and present. Jonathan Harb of Whiskytree conceptualized the look of the city ruins in 2D Photoshop files, which Asylum used as the basis for its post-apocalyptic CG environment, composited with a foreground location shot in New Mexico. Asylum used both 2D and 2 1/2D approaches to create the ruins, first laying out downtown Los Angeles and environs in Maya to determine an accurate geographic layout.



Asylum also made major effects contributions, including digital environments for a sequence in which executed murderer Marcus Wright (Sam Worthington) stumbles into the ruins of Los Angeles, unsure of both his past and

which ILM integrated into its digital environment. “When the helicopter stops rolling,” explained Snow, “it is upside down. Connor — now played by a stunt guy — releases himself from his safety belt and crawls out. The stuntman started that action and Christian Bale finished it, so we had to morph between them. The camera then pans over to see the last moments of the nuclear blast, created in CG. All of the surrounding dishes are in various states of destruction, a combination of miniature and digital matte dishes. Then we pan back onto Connor — this is still the same shot! — as he is confronted by the T-600, which has torn itself loose from the helicopter.”

Stan Winston Studio created a T-600 torso puppet for the scene, which was replaced in many shots by ILM’s CG model. “Because it was just a torso,” said Charlie Gibson, “with wires and rods hanging out the bottom, it was hard for the puppeteers to get an appropriate sense of weight out of it. It had to have a lot of force and fluidity, and sometimes we could get that better with the CG version.”

Even in shots in which the practical T-600 had to be replaced with the computer animated character, the puppet still provided ILM with invaluable reference. “It was great having the Winston T-600 puppet there on set,” said Ben Snow, “and we didn’t always have to replace it entirely. In some shots, we were able to use part of it, just replacing the head or an arm with CG. And even in shots where we had to replace it entirely, the puppet was a very good guide for us in terms of lighting and integration.”

For interactive purposes, production shot much of the fight between Connor and the T-600 with performer Brian Steele standing in for the terminator, wearing an iMocap suit ILM had developed for the last *Pirates of the Caribbean* film. Steele’s performance guided animation director Marc Chu and his team as they developed animation suggesting a less technologically sophisticated version of the original T-800 endoskeleton. “It had to move in a way that was a lot less human than the T-800,” related Chu, “more mechanical and monster-like. Also, we wanted the machines to seem like something they could really build, even today. This is 2018, not that far into the future, so the technology for all the machines had to be recognizable as current-day technology, using pistons, chains, hoses and similar types of things.”

present. Jonathan Harb of Whiskytrees conceptualized the look of the city ruins in 2D-Photoshop files, which Asylum used as the basis for its post-apocalyptic CG matte painting design. In an effort to provide more realistic altered environment composited with a foreground location shot in New Mexico, Asylum used both 2D and 2.1/2D approaches to create the ruins. First laying out downtown Los Angeles and environs in Maya to determine an accurate geographic layout.



In a montage sequence added late in production, bedraggled Judgment Day survivors, in encampments around the world, listen to John Connor’s broadcast message of hope. To realize the sequence, Charlie Gibson contracted Matte World Digital to extend minimal live-action sets – built on stage at Warner Bros. – on which he photographed small groups of performers. Partial sets included encampments in a jungle environment, a desert, and the interior of a subway station.



The plate for the subway station scene featured performers on an extremely small set that occupied only a corner of the soundstage. Given free rein to design the remainder of the environment for the stand-alone shot, Matte World Digital created a 2D mattepainting that included a collapsed ceiling and an extension of the set

“I wanted a relatable technology that felt like it came off the drawing boards of what could be in the works right now,” added McG. “It was critical to have that realism. I wanted a dirty, rough, grimy, difficult future — not a pristine, clean future with machines doing things that machines of our time cannot do.”

platform. MWD also built a fully 3D subway car to facilitate dramatic camera moves.

Sequence supervisor John Walker led the T-600's look development, while Bruce Holcomb sculpted the computer model and Ron Woodall painted it to match the matte finish of the Winston puppet. A new approach to lighting the T-600 and other CG characters, devised by Christophe Hery and CG supervisor Pat Conran, enhanced the machine's realism in the scene. “The basic idea was to do global illumination using high dynamic range images,” explained digital production supervisor Philippe Rebours, “which, of course, we'd done before. On previous shows where we had used global illumination, though, when we wanted more reflection here and there we would place a reflection card with a light shader. But that never gave us the correct diffusion or ambient aspect of the lighting. With global illumination, the HDRI environment is like a big sphere of lighting around your creature, but there is no information relating to distance — and distance is an important aspect.

“For this show, we had a set of shaders and lights we could place like the old reflection cards, except using high dynamic range images. We had tons of reference taken on set with multiple exposures that we could put on cards; and not only would that give us a reflection, it would also give us the appropriate diffusion. We could say: ‘Here's the geometry, this is the distance — and at that distance, what type of illumination would we have?’ Using photos taken on set, we could position our objects or lights at the proper distance and get the proper lighting.”

Fast turnarounds were aided by a ‘Graphic Library’ preview written by Pat Conran. “Internally, we call it ‘Layer Cake,’” said Rebours. “Using this preview, and doing graphic card renders very quickly, we could see if our lighting was matching. It was completely interactive, taking only about three seconds per frame to record; in five minutes, we could see our shot and the position of our light. We couldn't find all the lighting that way because of restrictions in the material sets and things like that. So on top of that GL preview, we had another preview that emulated RenderMan. We would use the GL preview to position and animate our lights, and then we would switch to the RenderMan emulation preview to tweak the materials and the light intensity.” Compositing lead Mark Nettleton and his team comped the CG T-600 into the fight scene after the paint department had removed Brian Steele from the plate.

Having radioed for help, Connor is picked up by a resistance Osprey helicopter and orders the pilot to take him to command headquarters, located on a submarine in the ocean depths. For the chopper's ocean approach, Charlie Gibson shot helicopter water plates off Santa Barbara and Malibu, and then turned them over to Rising Sun Pictures, which created a CG Osprey and other digital assets for the sequence. “There's a big establishing shot where the Osprey is flying over desert,” said RSP visual effects supervisor John Dietz, “and then the desert becomes water. Even though there were plates for that, we had to make the calm water in the plates look stormy. We also had to do some sky replacement.” After the establishing shot, Connor jumps out of the Osprey, into the stormy sea. “We did a full CG shot of the Osprey gliding down and a digital double of John Connor jumping into these raging big seas. We used Houdini for that.” Gregory Yepes, the supervisor

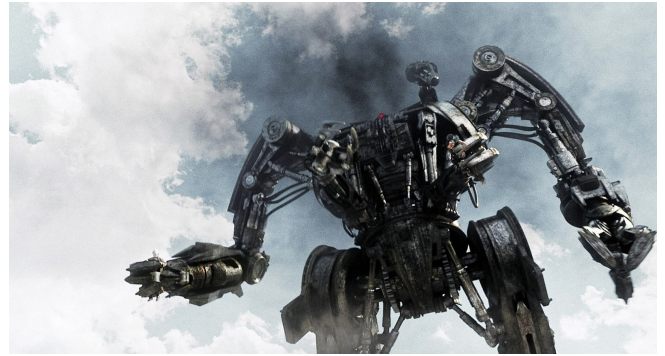
at RSP's Sydney office, supervised the sequence and led the development of simulated water and atmospheric interaction in Houdini. After Connor's jump, the scene cuts to an RSP all-CG underwater shot of the submarine, and then to live-action of Connor inside a sub interior set.

Back on land, Marcus Wright seems to appear out of nowhere, disoriented and unsure of where — or when — he is. Crossing the southern California desert, Marcus comes upon the ruins of Los Angeles, first conceived in concept artwork provided by Jonathan Harb of Whiskytree in the form of 2D Photoshop files. From that concept work, Asylum created post-apocalyptic L.A. environments in CG. "Jonathan's concept work set the tone," remarked Asylum visual effects supervisor John Fragomeni, "and then we took over the matte paintings and the development from there. McG wanted to see a really dilapidated, destroyed, gritty city — very depressing, end-of-the-world stuff."

Asylum used both 2D and 2½D approaches to create the views of L.A. in ruins. "We wound up doing 8K matte paintings," stated Asylum founder and visual effects supervisor Nathan McGuinness. "We laid out Los Angeles in Maya first to figure out where everything was in space; and so, when we pointed our cameras, the view was geographically accurate."

In the distance, Marcus spots the approach of what at first appears to be a man, but is soon revealed to be a T-600 thinly disguised in ragged clothes and a vinyl human face mask. On set, Brian Steele played the T-600 wearing a Stan Winston Studio suit that included endoskeleton parts and bluescreen areas that would enable Asylum to track in computer generated inner structures. "We wanted to create a fusion character," explained Charlie Gibson, "something that used the best of what Winston Studio had to offer, but also clearly could not be a guy in a suit. We purposely put proportions in that were non-human, such as a universal joint at the waist and socket joints at the shoulders, just to take the guy-in-a-suit look out of it."

Working with data provided by Asylum on-set supervisor Phil Brennan — who was present for the filming of all the Asylum effects sequences — Asylum designed, built and tracked digital T-600 machine parts to the blue areas of the SWS suit, extrapolating from the look of the practical T-600 puppet. "Charlie Gibson and McG ended up not liking the head they had on set," observed Nathan McGuinness, "and so we worked with Charlie to redesign that. The biggest challenge was just deciding what parts would be the practical guy and what would be CG. Every shot was different; but in each one, we had to integrate our CG T-600 perfectly so that you couldn't tell what was CG and what was real." Senior Flame artist Joe Ken was key to integrating the CG T-600 parts with the practical suit and environment.



Having heard the radio message, Marcus, Kyle Reese (Anton Yelchin) and the little girl Star (Jadagrace) drive toward Connor's camp, interrupted en route by a giant Skynet machine harvesting humans for experimentation. To realize the CG harvester robot, ILM started with art department concepts, then did a considerable redesign to make the machine look less humanoid. McG's overall brief was to give the harvester a retro look reminiscent of a World War II battleship, complete with oily, grimy surface textures and black smoke exhaust.

Marcus guns down the T-600, and that activity ultimately draws a hunter-killer — a flying machine first introduced in the future war sequence of *The Terminator* — dispatched by Skynet to kill teen-age Kyle Reese (Anton Yelchin) and his young companion, Star (Jadagrace). As the HK swoops low over the city ruins, the wash from the machine causes a crumbling building to collapse. Kerner Optical built and shot the building as a miniature, which Asylum then integrated with its synthetic environment. “We built a 1/18-scale building,” stated Nick D’Abo, “which was 24 feet tall by 12 feet wide by 10 feet deep, made out of pyrocel with a lot of aluminum in it. Geoff Heron rigged it so that it could be pulled down. He didn’t use pyro on this one because it was very important to Charlie Gibson that there not be too much dust in the shot. He wanted to be able to see the image; and then it would be up to the CG guys to add whatever dust they wanted.” To ensure the building would collapse appropriately, the model crew weakened it at key structural points. “We weakened it so much, it started to move a bit, and we realized, ‘We’ve got to shoot this now!’ So we jumped to it, and we got it — but that was another nail-biting moment, especially on a one-take deal.” Pat Sweeney served as director of photography on the toppling building.

From his base camp, John Connor broadcasts a radio message to the survivors of *Judgment Day*, rallying them to join the resistance and keep their hopes alive. In a montage added late in production, pockets of people in encampments around the country are seen listening to the message. Charlie Gibson contracted Matte World Digital to extend minimal live-action sets on which he had shot small groups of bedraggled survivors. “Charlie invited me to shoot plates with him on three different small sets,” MWD supervisor Craig Barron related. “One was a jungle, another was the interior of a subway station, and the third was a desert environment. Our job was to extend these partial sets and make them look like real environments. Charlie didn’t want the locations to look like specific establishing shots; he just wanted there to be a lot of contrast between the environments so that you’d get the sense that people from all over the United States were hearing John Connor’s broadcast. Since they were all stand-alone shots we had a lot of freedom to do the designs.” In addition to a 2D background, matte painter Eric Hamel created a fully 3D subway car for the station interior, facilitating more dramatic camera moves.



Another machine new to the Terminator universe was the moto-terminator – high-speed, two-wheeled, riderless vehicles that chase Kyle, Marcus and Star as they flee the harvester in a tow truck. To capture in-camera dynamics for the moto-terminator chase, production shot two Ducati Hypermotards racing down New Mexico roads. ILM erased the stunt drivers and bikes in postproduction, and replaced them with CG moto-terminators, designed and modeled to suggest a hunched-down T-600 on wheels. Special effects supervisor Mike Meinardus rigged full-scale pyrotechnics on location, simulating explosions of pipe bombs thrown by Marcus and Kyle from their truck.

Having heard Connor's message, Marcus, Kyle and Star jump-start a vehicle and drive toward base camp, stopping at a convenience store and gas station to stock up on fuel and food. There, they meet other survivors — some of whom are suddenly seized by a massive Skynet 'harvester' robot that smashes through the store walls and grabs them in its claws. Ben Snow and his team shot a reference plate of the intact gas station interior; and then the actors were cleared out and Mike Meinardus' team pulled two cross-shaped metal rigs through the set to simulate the harvester claws. "We filmed that," recalled Snow, "and then we cleared those metal shapes out and filmed just the holes that were left. We went to lunch at that point so that the stunt people could rig their gag for the people being pulled out through the holes; and when we got back from lunch we discovered that, to make it safer for the stunt people, they had cut square holes in the set, ruining the beautiful holes Meinardus had created with his metal shapes! They shot their practical elements of the stunt people being lifted out, mortars blowing harmless debris to help with the interaction. Then we reassembled all those separate passes, and combined them with our CG claws. It took a lot of hand paint work to put the interesting-looking holes back in over the bland square holes."



The chase continues onto a bridge over a deep canyon. An aerial hunter-killer fires on the bridge, forcing the tow truck to crash into the railing and tip over the precipice. On a partial bridge set, production shot the truck as it was lifted by a special effects rig. ILM enhanced the in-camera action, rotoscoping the truck from the plate and reprojecting it onto a CG truck model, and then animating it to perform a more dynamic tip and slide. ILM integrated the digitally enhanced truck with a CG bridge environment.

To realize the harvester, ILM started with concepts from Martin Laing's art department. "Mar-tin and his team did some really cool designs," stated Snow, "but as we got into building this thing, the filmmakers thought it looked a bit too much like something from *Transformers*. So Christian Alzmann and the art directors at ILM redesigned the harvester to make it a little less humanoid and less like an anim  giant robot. We got rid of its head and added some of the features we all loved from the ED 209 in *Robocop*. This was McG's monster, so it had to be somewhat anthropomorphic; but he also wanted it to have a retro look, like a *World War II* battleship — filthy, and pumping black smoke into the atmosphere." Animator Chris Mitchell worked closely with Marc Chu to bring the harvester to life.

Marcus, Kyle and Star escape in a tow truck, dodging plasma balls firing from the harvester cannons. McG rejected ILM's initial designs for the plasma fire as looking too futuristic and high-tech, and asked that they create an effect that tied into the retro battleship look of the harvester. "McG pulled up images from the Internet of battleship cannons firing," Snow said. "Extrapolating from that, we designed an effect that started with smoke being sucked in; and then the plasma ball would discharge, leaving another big puff of smoke in the aftermath." To create the look, compositors combined practical smoke elements with a CG laser-sighting element and CG lens flares. "When it hit something, a vehicle for example, there would be a practical explosion; but then we added distortion and warping and some hints of electricity to give it a subtle futuristic accent.

We also did some roto composite effects to make the vehicle glow for a couple of frames just before it exploded.”

In a scene reminiscent of *The Terminator*, Marcus, Kyle and Star use flares to blow up a fuel truck behind them, presumably destroying the harvester. Charlie Gibson shot a practical gas tanker on set; but ILM replicated it in CG to facilitate more dynamic action. The explosion of the tanker was a huge Mike Meinardus practical effect that obliterated the entire gas station set — an event so large, it was covered on that evening’s local newscast.

The harvester survives the fuel truck explosion and sends two wheeled ‘moto-terminators’ after the speeding tow truck. To shoot the moto-terminator chase, production filmed two Ducati Hypermotards racing down New Mexico roads. “We had them there for reference,” noted Charlie Gibson, “and to give us something to cut with. We wanted something that we could photograph from a helicopter and from our camera cars. Real stunt drivers on real bikes gave us a real sense of action; and then we erased the bikes and replaced them with digital ones. The action of the chase changed after we were in the digital world, but having something real there in the first place was still very valuable. You don’t get the same energy just working from storyboards and previz as you do shooting a real action sequence.”



Kerner Optical built and exploded 1/6-scale A-10 jets for an aerial dogfight in which resistance planes do aerial battle with hunter-killers between the walls of the narrow canyon. The setup on the Kerner stage included plane-mover rigs and tracks on which multiple cameras traveled to keep the A-10s in frame. Modelmaker Charlie Bailey and effects rigger Robbie Clot fill the interior of a plane miniature with debris in preparation for the pyrotechnic gag.

Martin Laing had designed a moto-terminator with the idea of retrofitting an existing motorcycle, but ILM altered the design in the digital realm and created a vehicle that was essentially a hunched-down T-600 with wheels. John Zdankiewicz led the moto-terminator animation, while Greg Salter was compositing lead on the chase sequence, which moves onto a bridge over a deep canyon, shot at the Taos Gorge Bridge. A hunter-killer flies into frame and fires, taking out a chunk of bridge and forcing Marcus to skid to a stop. *Hooked* to the hovering HK, the tow truck lifts up, causing Kyle and Star to fall out, over the side of the bridge. On a partial bridge set, production shot the truck being lifted by a special effects rig. ILM increased the angle of the lift and added more dynamic action, rotoing the truck from the plate and integrating it with its digital bridge environment. “We re-projected the truck onto a CG version,” said Snow, “and then we changed the performance of the truck to make it slide off the bridge.”

A harvester claw plucks Kyle and Star from the air and deposits them into the holding pen of the transport. Wide shots of the action featured ILM’s digital doubles, as well as the CG harvester and CG transport, all animated by Andy Wong, who led aerial animation. To rescue the kids, Marcus jumps onto the transport. “The transport ship was usually CG,” said Charlie Gibson, “but we built a full-size set piece, about the size of a shipping container, for shots of Marcus clambering around on the outside of it.” In wider shots, ILM animated a Marcus digital double atop a CG transport. For

subsequent shots of Marcus being grabbed by the harvester claw, Sam Worthington was suspended and swung about in a stunt rig, and shot against bluescreen.

Fired on by two resistance A-10 planes, the harvester releases Marcus, who falls to the bottom of the gorge, doing cartwheels across the river surface upon impact — the first hint that he might be something other than human. For reference, the ILM team looked for water skiing and boat accidents on YouTube. “Someone found footage of a boat crash,” said Ben Snow, “one of those long thin cigarette boats cartwheeling across the water. For awhile, we had that footage in the cut.” ILM replaced the boat footage with its cartwheeling digital Marcus, and created the water surface by stitching together tiles from HD footage shot on location. Composer Jason Porter blended in practical and CG splashes.

The planes disable the hunter-killer, which crashes into a canyon wall. Kerner Optical carved a 1/8-scale, 24-by-10-foot urethane foam canyon wall for the shot, and crashed a same-scaled HK mandrel into it; but the miniature element was ultimately replaced with ILM’s digimatte gorge environment. A second HK detaches from the transport and engages the planes in an aerial dogfight, a sequence assembled by compositing supervisor Jen Howard. “Originally,” related Ben Snow, “they asked if we could build this entire dogfight digitally. And we said: ‘Please, no. Don’t make us do that! Let us shoot aerial plates!’ Charlie and I did an aerial scout; then we planned the shots and realized that we could shoot plates for almost all of them.”

In the course of the dogfight, the HK takes out one of the A-10s, which explodes in midair. Kerner Optical constructed two 1/6-scale plane models for the sequence. “They were about nine feet long,” said Nick D’Abo, “with a ten-foot wingspan, and they were built in classic model airplane fashion. We did a highly detailed sculpt to create the molds, and then cast the pieces in fiberglass, which were assembled and painted.” Geoff Heron blew up the models, and also engineered the rigs on which the plane and cameras traveled. “We had rigs the plane flew on, and also rigs for the cameras to travel with the plane. We had multiple cameras — three or four — on each of the A-10 shots. Not all of the cameras were on rigs — some of them were just panning — but the hero cameras were always moving, traveling on track alongside the plane. The timings were critical because the hero camera had to be in just the right place at the moment that the plane blew.”

The HK fires upon the second A-10, piloted by Blair Williams (Moon Bloodgood), but the shot misses and takes out a giant chunk of canyon wall, raining rocks on the plane as it flies through. ILM integrated CG rocks, plane and HK into one of the aerial plates Ben Snow had captured on location. The scene continues with the HK firing on Blair’s plane again, this time disabling the aircraft in a fiery explosion — the CG plane combined with Kerner mandrel explosion elements. Production shot a closeup element on stage for a shot of Blair ejecting out of the burning plane; but a following wide shot of Blair in her ejection seat featured a digital double.

The action cuts to Connor’s base, where he is testing a device designed to scramble the electronics of Skynet hardware and thus disable the machines. In an earlier scene, Connor tests the device while his men examine a hydrobot, a water-based terminator. Stan Winston Studio built a practical hydrobot for the examination scene. “The hydrobot is seven or eight feet long,” described John Rosengrant, “and it’s a skeletal-looking thing, with a stinger tail and a head made of mandibles.” Trevor Hensley sculpted the hydrobot parts, which Richard Landon and Matt Heimlich machined

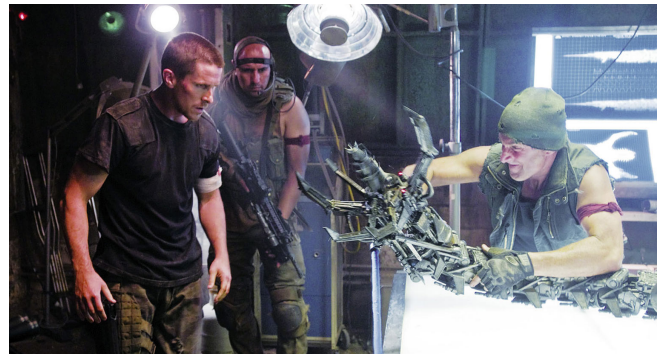
out of metal and then engineered to pivot and move at each spine joint. “On top of this functioning metal structure were hard, but slightly flexible urethane parts to give it the look we wanted.”

As Connor’s men attempt to hold it down on a table, the hydrobot writhes and snaps. “The day we shot this,” Rosengrant related, “I gave them a demonstration of how they could wrestle it on the table. McG liked what I was doing, and so he put me in the movie as one of the soldiers that was handling the hydrobot. That was the day after Stan had died — and so it was a very hard day for all of us. But it was also a galvanizing moment, because it gave us a chance to really live the ‘show must go on’ idea. We were determined to make Stan proud, to make this character look great in this scene; and so we all had to reach down and do it.”

Later, testing the scrambling device on bigger ‘game,’ Connor employs the beeping signal to disarm a hunter-killer’s tracking capabilities and send it crashing into the landscape. He then finishes off the disabled HK with a bazooka. Rising Sun Pictures took on the HK test sequence, which required a range of effects, and also the transformation of daytime footage into night. “The hardest part of this sequence was dealing with the day-for-night,” noted John Dietz. “All the backgrounds had to be painted, and we replaced all the skies. It became, essentially, a full-on environment replacement job, with a lot of matte painting and roto.” RSP augmented the physical effects gags executed on set, using Houdini to create additional fire and smoke around the crashing and exploding HK. “We also created the HK, which is fully CG when it crashes. Kerner Optical blew up a proxy model of the HK that they filled up with all kinds of debris, and we sweetened that with our CG explosion.”

Having met Marcus at the bottom of the gorge after ejecting from her aircraft, Blair leads him to Connor’s base, crossing a mine field at the camp’s perimeter. As Marcus crosses, a landmine explodes, tearing at the flesh of his torso and exposing the metallic ribcage of a terminator endoskeleton. With the discovery that Marcus is part machine, Connor suspends him, by chains, in a missile silo.

Asylum designed, built and tracked 3D endoskeletal structures to blue-painted sections of Sam Worthington’s abdominal area, which were ringed by torn-flesh prosthetics created by Stan Winston Studio and supervised on set by Mike Smithson. Though these metallic understructures would resemble the T-600 and T-800 endoskeletons, McG and Charlie Gibson had requested that Asylum design a unique look for Marcus. “They wanted him to look more high-tech than the original Stan Winston version,” said John Fragomeni, “so we redesigned the ribs, and added some sophisticated electronics — what we termed ‘nanotechnology.’” As Asylum artists began replacing the blue areas with the CG structures, they found that to blend them with the prosthetics required a bridging element of CG flesh. “The



John Connor observes as one of his men – played by Stan Winston Studio creature supervisor John Rosengrant – struggles to subdue a captured ‘hydrobot,’ a water-based terminator with long, eel-like body and multiple mandibles at the head. SWS built hydrobot puppets for this and a later river attack sequence, which also featured ILM CG versions. Parts were machined out of metal, then assembled and engineered to pivot at each spine joint to facilitate a serpentine swimming motion through water. On-set puppeteers created body movements via rod manipulation, while the head was cable-operated in one version of the puppet, and driven by air cylinders in another.

bluescreen areas and fleshy prosthetics became a guide as to where the damage should be, but we replaced everything digitally, even the flesh appliance. We used it as a real edge, but underneath it, where it joins with the metal, we added CG meat.” At McG’s behest, Asylum also expanded the blue matte areas to expose more metallic understructure than originally planned.

Due to the evolving nature of the Marcus endoskeleton, Asylum used Houdini, rather than its usual Maya pipeline, to create the effects. “We used Houdini Digital Assets,” explained CG supervisor Sean Faden, “which allows you to create building blocks of different functions. For instance, we had a Digital Asset that just handled the animation rig, and another that just handled the lighting. It allowed lighting lead Denis Gauthier to add new moving parts into a setup that was already in production.”

“Houdini is very procedural,” added rigging lead Jeff Willette, “so we were able to do a lot of changes in the design, even as the animators were already working. It allowed us to be very flexible and to work very quickly — and considering how tight the schedule was, I don’t know that we could have done this any other way.” Lead Flame artist Mark Renton massaged the shots, integrating Marcus’ beating heart and metallic structures into the high-contrast lighting of the silo set. Asylum also extended that small set, surrounded by bluescreen, in CG.

Convinced that Marcus is not a Skynet agent, Blair aids his escape on a motorcycle. Connor and his men give chase in a helicopter, dropping napalm on a large river area to destroy the half-man, half-machine. Asylum completed plates shot at a water tank set, which included a minimally dressed riverbank and several burning trees. “We extended the burning trees in some shots,” said John Fragomeni, “particularly the aerial shot where you see the big napalm drop. We created the surrounding forest in this big 2½D view. Also, the water tank they shot was square; and so, we created the shape of the river itself, complete with moving water surfaces.”

As the helicopter hovers near the river’s surface in search of Marcus, the pilot bends low to drop a flare into the water and is suddenly yanked into its depths by a hydrobot. More hydrobots swarm the helicopter cockpit, chewing through the control panels and causing the helicopter to crash in the river. Asylum completed the crash sequence, which starts with the helicopter spinning — achieved by Meinardus’ crew mounting a helicopter shell to a spinning gimbal rig, shot against bluescreen. Asylum removed the rig and added digital backgrounds. “We strung together ten to twelve exterior shots leading up to the actual crash,” said Sean Faden. “They had



Marcus sustains a series of injuries that tear at his flesh and reveal a mechanical terminator substructure. Asylum designed and built 3D endoskeleton parts, and tracked them to blue areas of Sam Worthington’s face and body, also made up with Stan Winston Studio torn-flesh prosthetics. Though the metallic structures resembled those on previous endoskeletons, Asylum designed a more high-tech look for Marcus — as per McG’s and Charlie Gibson’s direction — developing a system of ‘nanotechnology’ electronics to drive the cyborg. To better integrate the mechanical parts with the character’s

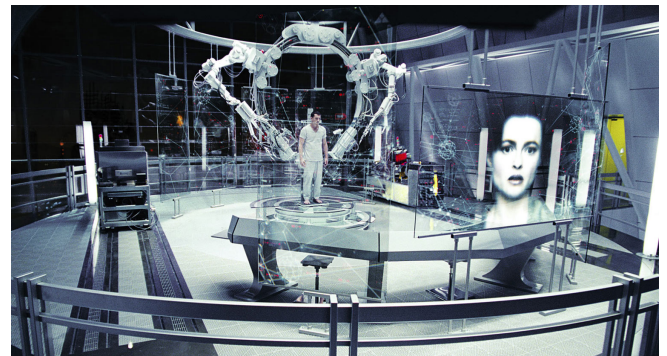
bluescreens on the outside of the helicopter windows so we could add the spinning shoreline environment. We projected a 2D matte painting onto 3D geometry for that — and so it was 2½D, with the lighting baked in. We also added a lot of burning trees on cards in the background. We dirtied up the helicopter windows, too, and added 2D water vapor and rotor wash.”

For the actual crash, Meinardus mounted the real helicopter on speedrail, suspended from a crane, and dropped it into the water. “As the helicopter hits the water,” stated John Fragomeni, “the blades shear off and fly toward camera with debris — that was all our CG animation. We’ve got CG water in there, as well, which we did using RealFlow from RenderMan.”

The filmmakers realized the hydrobot attack, in part, using the Winston puppets — shot on the tank set for some shots, and against bluescreen for others. ILM painted out puppet rod controls, and also populated the scene with CG hydrobots for the most dynamic shots, such as underwater action of hydrobots attacking Connor. Compositing lead Conny Fauser composited the animated hydrobots into water tank footage. “We see the hydrobots from many different angles,” said Jeff Sutherland, “above the water, into the water, under the water — and we had to create the right look for them in each of those situations. Conny worked with technical director Natasha Devaud to create the look of the hydrobot underwater, adding particulate to the water plates to give it the desired murky look.”

Connor is about to succumb to a hydrobot when Marcus — now with much of his face burned off in the napalm fires — arrives and destroys it. In the first two *Terminator* films, half-Schwarzenegger, half-endoskeleton shots had been achieved using metallic-looking facial prosthetics; but for *Terminator Salvation*, Asylum tracked its 3D terminator skull to blue areas affixed to one side of Sam Worthington’s head. “It was very difficult to do,” said John Fragomeni, “because you see half of his head missing, and you see his jaw moving when he talks. You actually see into this guy’s skull, in closeup, so there was a lot of detail work. We went through many iterations of how much nanotechnology we would see, many iterations of burned, sizzled flesh — although it couldn’t be too horrific, because of ratings.”

wounds. Asylum ultimately replaced much of the prosthetics work with CG skin. Marcus sustains a series of injuries that lead to his flesh and reveal a mechanical terminator substructure. Asylum designed and built 3D endoskeleton parts, and tracked them to blue areas of Sam Worthington’s face and body, also made up with Stan Winston Studio torn-flesh prosthetics. Though the metallic structures resembled those on previous endoskeletons, Asylum designed a more high-tech look for Marcus — as per McG’s and Charlie Gibson’s direction — developing a system of ‘nanotechnology’ electronics to drive the cyborg. To better integrate the mechanical parts with the character’s wounds, Asylum ultimately replaced much of the prosthetics work with CG skin.



Marcus makes his way to Skynet headquarters, situated within the ruins of San Francisco, and gains access to a laboratory established by Cyberdyne scientist Serena Kogan (Helena Bonham Carter), a pioneer in the creation of the human-like infiltrator terminator. After being repaired and made whole inside Serena’s lab, Marcus interfaces with an image of the scientist on a large monitor. Imaginary Forces designed and created graphics seen throughout the Skynet sequence — which Asylum tracked into shots — and also created ‘machine vision’ graphics representing the POVs and data interpolation of terminators and other Skynet hardware seen throughout the film.

A wary truce is reached between the two men when Marcus assures Connor that — as a machine — he can get him into the heart of Skynet's headquarters. ILM created wide shots of Marcus arriving at Skynet, an industrial complex situated on the rubble of what was once San Francisco. At the center of the complex is 'Serena's lab' — the workplace of the Cyberdyne scientist who visited Marcus in his death row cell. Working from production art department concepts, Christian Alzmann designed the exterior of Serena's lab as a gleaming tower surrounded by a wasteland of industrial machines, factories and refineries.

ILM created another wide view of Skynet amidst the San Francisco ruins for a shot of Connor crossing the Golden Gate Bridge on a moto-terminator. Production provided ILM with an aerial plate of Christian Bale riding the practical moto-terminator on a generic road outside Albuquerque. "We started on his face with the helicopter shot," stated Ben Snow, "and then pulled out to a reveal of Skynet and a somewhat destroyed Golden Gate Bridge, which was a big matte painting that Kevin Page executed. It is a unique view in that there are no lights, except for the moonlight and the flames coming out of the refinery towers. It is a very smoky, hellish environment." To inform the look of the city ruins, the matte team — led by Giles Hancock — referenced photographs of 9/11 destruction, as well as the wrecked landscapes of Dresden after the bombings of *World War II*.

As Marcus and Connor infiltrate Skynet, the action cuts to the submarine interior of resistance command, where leaders realize — too late — that their scrambling device, meant to disable Skynet machines, has instead enabled Skynet to track them. In a sequence realized by Rising Sun Pictures, a low-cruising hunter-killer destroys the submerged submarine in a massive explosion. "We created the HK, the plasma ball fired by the HK, and the submarine for that sequence," said digital effects supervisor Sean Mathiesen. "For the shot of the HK flying over the water, there's some live-action ocean that Charlie Gibson shot; but the HK was CG. Then there is a long tracking shot, full CG, as the plasma ball splashes into the water and hits the sub." New Deal Studios contributed to the shot, filming an underwater tank element of a submarine-shaped buck exploding. Rising Sun then skinned the buck element with its digital submarine.

In Serena's lab, Marcus interfaces with an image of the scientist on a large monitor. Imaginary Forces designed and created the network graphics seen in the Skynet sequence — which Asylum tracked into shots — and also created the 'machine vision' graphics representing the POVs and data interpolation of terminators and other Skynet hardware seen throughout the film.

Deep within Skynet, Connor discovers a factory where T-700 terminators are being constructed. McG filmed the sequence at a disused power plant in Albuquerque, dressed with Stan Winston Studio terminator props. ILM extended the set and augmented the Winston endoskeletons with animated ones moving along the assembly line.

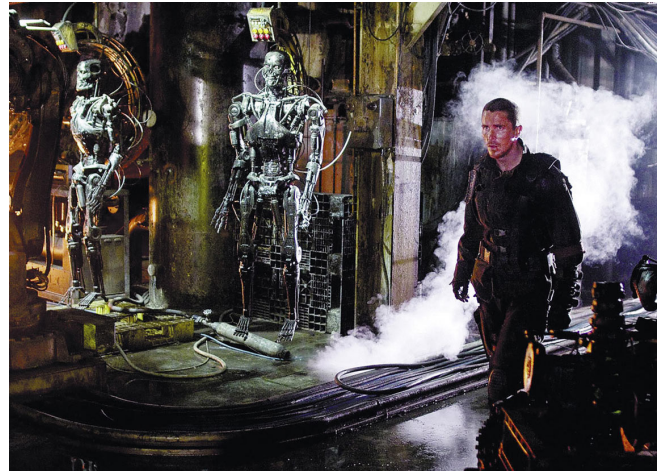
From out of the shadows of the terminator factory emerges the completed 'Arnold Schwarzenegger' T-800 introduced in *The Terminator*. Clear shots of the character were relatively late additions to the scene, which had originally been storyboarded to reveal only a muscular body, the face obscured in dim lighting. The scene was then to continue with Connor unloading a round of machine-gun fire into the terminator's face, so that it would appear as an endoskeleton skull when it stepped into the light. Production had shot Roland Kickinger — who resembled young Schwarzenegger and had

portrayed him in a 2005 television biopic, *See Arnold Run* — on the factory set, with the intention that ILM would track an endoskeleton head to his body.

Fan input changed that plan. “As we were shooting,” said Ben Snow, “McG gave a talk at Comicon or some similar event, and the fans were so enthusiastic about the idea that there might be some representation of Schwarzenegger in the film that, afterward, McG came to us and said: ‘We have to do it. We have to find a way to get Arnold in the film.’ Suddenly, rather than two or three shots of a very dimly lit terminator that might or might not be Schwarzenegger, we had more than ten shots of a fully visible Arnold, some super closeups. Instead of tracking the endoskeleton to Roland’s face, we were going to have to track a fully digital Schwarzenegger to his face.”

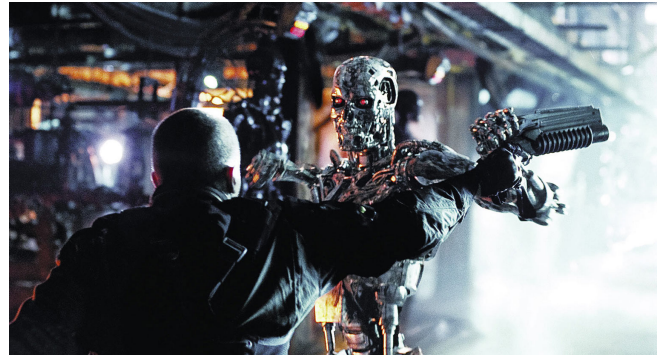
Whereas a facility would normally require a year or more to match an actor and develop a human performance in CG, ILM was left with less than six months to achieve the goal. “We had been toying with digital humans prior to this,” said Snow, “pushing our digital double technology. But once these fully-lit closeups of the Arnold T-800 were added, our digital double project suddenly became a digital human project. But we didn’t have the advantage of Governor Schwarzenegger driving a mocap session, like Brad Pitt had done for Benjamin Button; and we couldn’t have Roland drive the mocap sessions, because, although he resembles Schwarzenegger, he doesn’t look enough like him, facially, to make that really work.”

With these performance capture options unavailable, Snow turned to a technique Peter Jackson had employed on *King Kong*. “When we were trying to get Kong nailed down,” Snow recalled, “Peter Jackson and Fran Walsh went through a ton of footage of gorillas and picked out specific actions and behaviors: ‘Okay, this is Kong when he’s angry; this is Kong when he’s sad,’ et cetera. We had about 25 different clips that they gave us — and those, together with Andy Serkis’ facial performance, gave us Kong’s performance. I pitched to Charlie and McG that we do a similar thing here — take footage of Schwarzenegger from *The Terminator* and *Commando* and other movies he made around that time and find hero moments in which Schwarzenegger was doing actions that were most appropriate to the T-800 performance. We’d use those clips of performance as a guide to animating the Arnold head.”



To prove his loyalty to the resistance cause, Marcus aids John Connor’s infiltration of Skynet. Deep within Skynet’s industrial complex, Connor discovers a terminator factory where hundreds of T-700 models are being assembled by the machines. McG filmed the sequence at a disused power plant in Albuquerque, dressed with Stan Winston Studio terminator props. ILM extended the set in postproduction and augmented the practical endoskeletons with animated ones moving along the assembly line.

“We searched for references of Arnold expressing the particular emotion we needed for the shot,” added Marc Chu, “and from the same camera angle. Our animators had the reference right up there on their monitors not only for performance cues, but also to make sure our CG Arnold was staying on-model from each specific camera angle. We also used it for lighting cues and rendering.” Model lead Giovanni Nakpil created the digital Schwarzenegger head, working from photographs of the actor from the 1980s, as well as from a scan of a Schwarzenegger head maquette Stan Winston Studio had produced during the production of *The Terminator*. Modelers also built a library of facial shapes for animation, led by Jakub Pistecky, who keyframed the facial performance of the digital Arnold. Greg Jonkajtys created texture maps for the digital human head, while Pat Meyers developed synthetic skin and Jeff Hatchell created digital hair. Chad Taylor led the compositing of the digital Arnold in the scene.

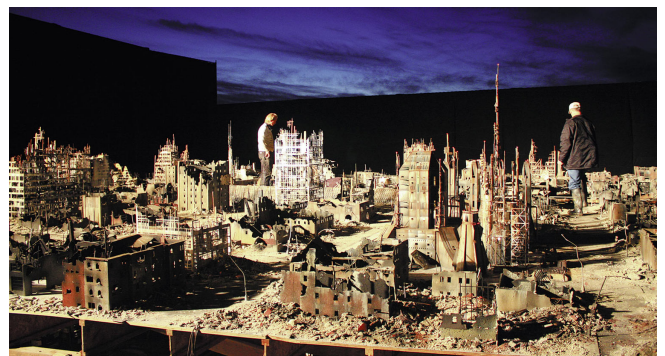


Connor engages a T-800 in battle within the factory. First appearing as the ‘Arnold’ version – shots ILM achieved by tracking a 3D Schwarzenegger head to a bodybuilder’s body – the terminator is flayed to its endoskeletal form after Connor fires on it with a machine gun. McG updated the T-800 design slightly to ramp up its physical prowess and take advantage of dynamic behaviors made possible by computer animation. ILM compositors painstakingly integrated the hero terminator into the factory environment – which featured smoke, sparks, flames and small explosions – by breaking up the character into separate pieces and lighting each individually, frame by frame.

Due to legal and rights issues, the fate of the character’s appearance in the movie remained unresolved until just weeks before it opened. As a result, ILM had to produce two versions of the sequence: one that included the fully visible Arnold, and another that adhered to the original storyboards, with the character remaining hidden in the shadows until it is primarily an endoskeleton head atop Kickinger’s muscled body.

Damaged by rounds of gunfire, the ‘Arnold’ terminator’s flesh is torn away, and the fully CG T-800 endoskeleton is revealed — an updated version of the iconic figure. “McG made a few tweaks to the original design to make it a little more physically imposing,” Charlie Gibson said. “This movie was an opportunity to show the endoskeleton in all its glory. We never got a great look at it in the two Cameron *Terminator* movies; and it was only shown in flashbacks in *Terminator 3*. To finally build a whole sequence around the endoskeleton, to see it really moving and living was just great. We were finally able to give it a real personality and make it a substantial villain.”

In accordance with the slightly altered design, Bruce Holcomb and his team added many more moving parts to the endoskeleton, and creature development supervisor Eric Wong rigged it to allow for more points of movement. But although computer animation would facilitate endoskeleton movement that was more complex and dynamic than ever before, the animators were also aware that



— for continuity purposes — the endoskeleton behaviors could not stray too far from those achieved with the original puppets. “We had to walk a really fine line,” observed Marc Chu. “We constantly looked at reference, from the first Terminator especially. There are a lot of amazing shots in that movie, where the Winston endoskeleton had a very nice mechanical, non-human feel, and we wanted to bring that into the CG character. It would have been very easy to make our CG T-800 move fluidly, but that wasn’t the look of the terminator.”

The T-800 and Connor engage in hand-to-hand combat, fight action staged on set with Christian Bale or his stunt double and a terminator stand-in wearing a special gray suit. “We filmed gray-suited guys mostly to give the actors someone to grapple with,” said Ben Snow. “It gave us a great guide for what the performance should be like, but we didn’t actually use it as motion capture material. Marc Chu’s team reanimated all of that, sometimes matching the original performance quite closely, sometimes changing it quite a lot.”

Integrating the CG hero terminator into the factory environment — which included smoke, flying sparks, flames and small explosions — was a painstaking process. “We got a lot of the flashing from the lighting of the creature,” said Jeff Sutherland, “and then it was a matter of simulating that flashing on haze layers around the terminator. We had to divide the creature up into several pieces: his right shoulder might have a certain level of haze that was being lit primarily by a fire in one corner of the frame; his arm would have another color and another level of haze. We had to go through frame by frame and do a lot of detailed compositing work to get that to fit in there nicely. Katrin Klaiber was the comp lead on the terminator factory, and she was instrumental in coming up with those integration techniques.”

After besting the T-800 with the help of Marcus, Connor rigs nuclear fuel cells to detonate, leveling the entire Skynet complex. ILM designed and created shots for the Skynet destruction, integrating Kerner Optical miniatures with digimatte environments. ILM realized a wideaerial view of the Skynet buildings amidst San Francisco ruins via miniature photography of a 1/48-scale Kerner cityscape. Kerner’s miniature photography crew shot the set with multiple Photosonics cameras to enable ILM to experiment with different film speeds when assembling the sequence.



For the first Skynet destruction shot, Kerner built the tower housing Serena’s laboratory in 1/24-scale and mounted it on a platform. Clad in very thin glass, the structure was pre-scored to break apart in specific areas with the firing of pyrotechnic charges.

Connor lobbs a grenade into a vat of molten metal, covering the endoskeleton in the liquid matter, and immobilizing it as it cools. To shoot the scene, production shot backlit methocel elements on a partial terminator factory set. ILM used those elements for a couple of initial shots, but segued quickly to a high-resolution fluid simulation generated by Lee Uren. “Lee ran the high-resolution fluid sim over the T-800 model,” stated Ben Snow, “and then Bruce Holcomb resculpted it to make a blobby version, which Ron Woodall painted. David Meny did great look development on that to make it look like a molten metal version of the terminator.”

The terminator breaks free and continues its attack, until Marcus finally rips off its head and destroys it. Connor — mortally wounded by a rod through his heart — and Marcus make their way out of the Skynet complex to awaiting resistance helicopters.

From the aerial vantage point, we see the destruction of Skynet — the result of Connor’s having rigged multiple nuclear terminator fuel cells. ILM designed and created four shots for the Skynet destruction sequence, integrating miniatures provided by Kerner Optical into background matte paintings.

For the first shot, Kerner built a 1/24-scale Serena’s tower, with surrounding structures, and mounted the 20-foot-tall tower onto a 25-square-foot deck. “We built a steel structure and then clad the whole tower in slide glass,” stated Nick D’Abo, “which is super-thin glass used for microscopes, and some acrylic. It was all prescored so that it would break apart when it was hit by Geoff Heron’s pyro.” To sell the idea of a nuclear event initiated in the bowels of the terminator factory, Heron rigged smaller explosions at the base of the set, followed by a series of larger explosions chasing up the 35-story tower.

After the tower explosion, the action cuts to a wide view of the shockwave traveling over a larger expanse of the city ruins — a view realized with a second 1/48-scale set that measured roughly 50-by-50 feet. “It comprised about eight square blocks of ruined buildings,” noted D’Abo. “Pat Sweeney shot that using multiple Photosonics cameras so that Charlie Gibson and Ben Snow could play with the speed as they saw fit, once they put the sequence together.” ILM extended the miniature sets with background matte paintings that included the Golden Gate Bridge and the Transamerica Building, and enhanced the photography with CG destruction and debris.

At a MASH field unit, Marcus sacrifices his heart so that Connor’s life can be saved — a gesture that at once proves his humanity and ensures the survival of the resistance. The last shot of the film, created by Matte World Digital, reveals a resistance helicopter — carrying a post-op, healing John Connor — as it flies into a subtle sunset. “They shot a real helicopter taking off,” said Craig Barron, “but against an overcast sky that just wasn’t dramatic enough for the last shot of the movie. So



To sell the idea of a nuclear event initiated within the bowels of the terminator factory, Kerner rigged smaller explosions at the base of the set, followed by a series of larger explosions chasing up the 35-story tower. ILM extended the view with miniature photography of the 1/48-scale city set and matte paintings, and enhanced practical explosions with CG smoke and debris.

Charlie asked us if we could make the shot more heroic looking. We replaced everything in the background with a 3D matte painting by Chris Evans, based on the Trona Pinnacles area in the Mojave Desert. Charlie also wanted to change the path of the helicopter, so we used only the interior and characters, replacing the exterior helicopter with a full CGI version built by Morgan Trotter, Luis Hernandez and Glenn Cotter.”

With its familiar visual motifs — flares and pipe bombs tossed out vehicle windows, high-speed truck chases and explosions, vats of molten metal, advancing chrome endoskeletons — and its strict adherence to the *Terminator* mythology, *Terminator Salvation*, in the end, was as much an homage to the original James Cameron films as it was a continuation and expansion of their narratives.

“*Terminator 2* was the film that made me say, ‘I must be a filmmaker,’” McG recalled. “I had such respect for that film, and the others, that when I was first preparing to make this movie, I went to Jim Cameron and asked for his permission, frankly, to move forward with the idea. If he’d been overtly against this film being made, I would not have made it — that’s how much respect I have for him. And though he gave that permission, he also said — in a way that only Jim Cameron can — ‘I reserve the right to hate it.’

“But then he went into the story of when he was going to do *Aliens*, and people said, ‘Who does this guy Jim Cameron think he is, following the great Ridley Scott?’ He knew that he could honor the mythology and give the fans what they were looking for while also furthering the story, and history has proven he was right. I’d never be so bold as to compare what we’ve done to that — but we certainly tried to. We worked diligently to honor the original films while furthering the story. And the film will speak for itself.”

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Marcus and a mortally wounded Connor escape the conflagration via a resistance helicopter. ILM composed the shot, creating a CG helicopter and a digital matte painting with pyro-laced Kerner miniature in the background. The two heroes are finally delivered to a MASH field unit, where Marcus sacrifices his still human heart so that Connor’s life can be saved – a courageous gesture that ensures the survival of the resistance.

Blood Brothers

ARTICLE BY JODY DUNCAN

Riding on the successes of three previous films based on the Marvel X-Men comic book series, director Gavin Hood, Marvel Entertainment and 20th Century Fox took a step back in time to recount the story of how mutant James Logan (Hugh Jackman) became the steely, indestructible *Wolverine*. *X-Men Origins: Wolverine* starts with a prologue set in the Canadian west in 1845, with Logan as a sickly child. A domestic fracas ends with the death of the man he has known as his father, and the unhappy revelation that he is actually the spawn of the groundskeeper — and thus half-brother to young Victor Creed, played as an adult by Liev Schreiber. want to be paralyzed by it, creatively. I was very fortunate that Roberto Orci, one of my writers, was a huge Trek fan. He made sure our story honored the series' legacy. At the same time, I felt the movie had to work on a more urgent, visceral level as a stand-alone entity.” brooding young Victor Creed, played as an adult by Liev Schreiber.



X-Men Origins: Wolverine tells the back story of mutant James Logan (Hugh Jackman) and his ascendancy to membership in the X-Men. The film – derived from the Marvel comic series and directed by Gavin Hood – starts with Logan as a boy, traumatized by the death of the man he has known as his father. To realize bone claws that protrude from the hands of the anguished youth, production hired Amalgamated Dynamics Incorporated to provide claw prosthetics worn by child actor Troye Sivan. Design changes in postproduction led visual effects supervisor Pat McClung to replace the practical claws with digital versions created by Rising Sun Pictures.

Bone claws protrude from the hands of the anguished young Logan. Amalgamated Dynamics Incorporated created a number of makeup effects for the production, including claw prosthetics worn by child actor Troye Sivan in the prologue and, in later scenes, by Hugh Jackman; but design changes during shooting complicated matters. “A.I did a lot of designs for the bone claws,” recalled visual effects supervisor Patrick McClung, “and built some that were akin to the bone claws in the comic book — but those didn’t read very well on film, because they were rounded, like chop sticks. We wound up replacing the prop bone claws with redesigned digital claws by Rising Sun Pictures.”

Rising Sun referenced the practical claw to model and light its digital version. “We ended up going with something that was a hybrid of our own design and the ones that had been provided to us,” related RSP visual effects supervisor Tom Proctor, “but the texturing and look of the claw surface all came from us, after a bit of experimentation. We had versions where you actually saw the bone developing when the claws came out. But we had to abandon that. Now, you see a little bit of the veins beneath the surface, and they have some translucency, but they look like mature, formed bone. Most of that work was done by Nick Pitt-Owen, our modeler/texture painter.” The protrusion of the bone claw is preceded by a warping and rippling of the skin on the boy’s hand. “We created some 3D passes to apply the warp, but the warp itself was done in 2D. Then the claws push up between his knuckles and break through the skin.”

Traumatized, young Logan and Creed run away, tearing through the woods as opening titles roll. The title sequence continues with imagery of the brothers as grown men, fighting in a series of wars. Hydraulx helped to realize the montage, which starts with a Civil War battle. “We shot this battle in a big field outside Sydney,” said Pat McClung, “but we didn’t have enough extras, of course; and so Hydraulx added a lot of extra people in the background via Massive, as well as smoke and dust elements to fill in the background holes. There’s a shot where Logan gets hit in the chest with a cannonball, and that propels him off screen; and when he falls back on screen we’re in World War I. We shot just a little bit of foreground for that, and Hydraulx added the whole background to greenscreen.”

“That was one of our toughest shots,” observed Hydraulx visual effects supervisor Erik Liles. “We had Hugh Jackman on the greenscreen stage, and we digitally built burnt-out buildings all around and a church in the background. The camera then whip-pans over to see a CG biplane being shot down, and we follow it as it slams into the church tower. That’s a fully synthetic shot, with a 2D ground plane and 3D planes, buildings and explosions. The only thing that is real is the foreground Logan.”



Major William Stryker (Danny Huston), a shadowy operative, recruits the grown Logan and his half-brother, Victor Creed (Liev Schreiber) – who has extraordinary powers of his own – to be part of a government mutant hit squad. The team’s first mission takes them to Lagos, Nigeria, in search of the source of adamantium. Hatch FX matte-painted aerial views of the Lagos shantytown and its surroundings –as seen from the mutant squad’s jet aircraft – and also extended a partial shantytown set shot in Vancouver with a 3D synthetic background.

A transition to *World War II* begins close-up on the brothers, the camera pulling out to find them on a personnel carrier landing on Omaha Beach. “We shot the beach in Sydney,” commented Pat McClung, “and we had a little bit of a set and one landing craft. Hydraulx added 3D landing craft, Massive soldiers, and ships on the horizon.” Soldiers storm the beach, and the action cuts to gun emplacements on the hillsides, shot on greenscreen sets and extended with 3D background elements and Massive soldiers. “Creed starts shooting into a pillbox gun emplacement, and we transition from his machine gun to a machine gun that is now in a helicopter in Vietnam. The helicopter was a Huey shell mounted to a gimbal — built by our physical effects supervisor, Dan Oliver — to roll it and spin it around.” The gimbaled helicopter was backed by nearly 300 feet of greenscreen, which Hydraulx filled with another 3D matte painting featuring Massive soldiers and villagers. “Hydraulx also put in the windows of the helicopter — we’d had to pull them out when we realized they were reflecting every light on the stage — and added a rotor to the helicopter shell.”

Creed’s bloodlust leads him to kill one of his own men, and he and Logan are sentenced to death by firing squad; but when their mutant powers immediately heal their gunshot wounds, they are thrown in jail, where Major William Stryker (Danny Huston) recruits them as part of a mutant hit squad. Their first mission takes them to Nigeria, along with a team that includes Wade Wilson (Ryan Reynolds), a wizard with blades, muscle-man Frederick Dukes (Kevin Durand), expert gunman Agent Zero (Daniel Henney), John Wraith (will.i.am) who is able to teleport, and electricity-wrangler Chris Bradley (Dominic Monaghan).

A.I. designed makeups for mutants seen throughout the film. Among the company’s creations was a muscle suit to bulk up Kevin Durand’s character. “Kevin is six-foot-five,” said A.I. supervisor Tom Woodruff, “a real strapping, athletic guy with a great attitude. We built a muscle suit to give him an outrageous bodybuilder build. It was a slip-on bodysuit, sculpted by Hiroshi Katagiri, with a neck piece that went on to thicken his neck.”

A.I also designed the makeup for Creed, which included slightly elongated canine teeth and long, cat-like nails. “One set of nails looked like they were retracted,” said A.I supervisor Alec Gillis, “like a cat’s retracted claws. We did a second set that was already extended in full fighting mode. These were prosthetic tips that we could glue on his fingers and blend off. We also created pairs of full silicone hands that he could slip on like gloves — both retracted and extended versions — which cut the makeup time down. Since they were made out of silicone they had a natural translucency and movement.”

Shots of the mutant squad’s jet in the night sky, executed by Cinesite, were followed by matte-painted aerial views of Nigeria created by Hatch FX. “The aerial shot shows a shantytown in Lagos, Nigeria,” said Pat McClung. “Then we crane down out of that to a set shot in Vancouver with a little bit of foreground shantytown dressing. The rest is all 3D matte painting by Hatch, which created all of these heavily fortified gun emplacements and so forth.”

As the squad infiltrates a building and confronts diamond smugglers, each member has an opportunity to showcase his particular mutant power. “Stryker first sends out Agent Zero,” related McClung, “who tosses and shoots multiple guns — 3D guns created by Soho VFX. Then Stryker sends in Dukes, who jams his fist into the barrel of a tank cannon, blowing up the tank. Then they go into the top floor of the building where people are sorting diamonds, and Ryan Reynolds’ character uses a double-sided sword to deflect bullets, killing the diamond smugglers with their own bullets.” Soho VFX added dynamic CG blades to the shots.

Wraith uses his teleportation abilities to disable the ring’s leader. Hydraulx realized the teleportation effect through a combination of 2D and 3D. “Wraith teleports in a fraction of a second,” noted McClung, “but in that split second he erodes away and his skeleton appears very briefly. The last thing you see is a pinpoint of energy. And then, when he arrives at his new spot, it is the reverse of that: you see the pinpoint of energy, you see his skeleton briefly, and then his body fills back in on top of it.”

The object of the raid becomes clear when Stryker questions the ring’s leader about a rare rock we later learn is the source of adamantium. When innocents are killed in an attack on a village where the rock was found, Logan quits the team, leaving Creed behind. The film cuts to six years later, to a cabin in the Canadian Rockies, where Logan is now living a simple life as a lumberjack with his girlfriend, Kayla (Lynn Collins). The production shot exteriors for the wooded scenes in Queenstown, New Zealand.



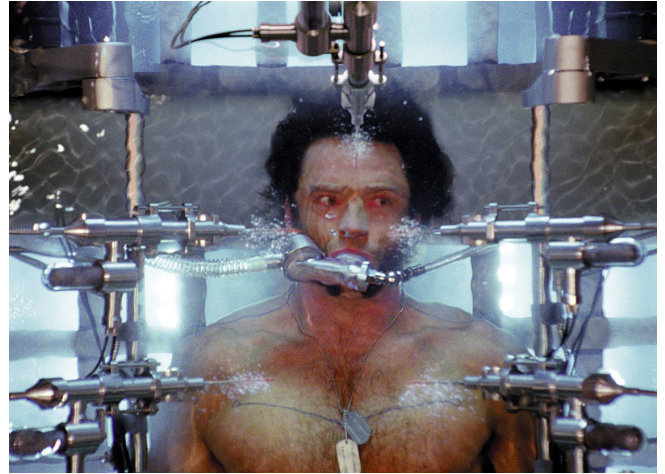
When Creed murders Logan’s girlfriend, Kayla (Lynn Collins), Logan agrees to submit to an experimental procedure that will bond indestructible adamantium to his skeletal structures, giving him the strength to kill his more powerful half-brother. For a shot of Stryker and Logan arriving at a government compound where the procedure will take place, Rising Sun Pictures created a CG establishing view that included a lake and dam, a sweeping mountain vista and a concrete landing platform. A foreground element of a real metal door in a cliffside was shot in Australia.

The narrative jumps to a small-time carnival in Springfield, Ohio, where Bradley showcases his electrical manipulation powers before being murdered by Creed. Rising Sun created a night matte painting of the carnival and its surroundings. “There was a plate shot with a small carnival set,” said Tom Proctor, “and we had to extend that, adding lights to augment the practical set lights. Then, later, when Bradley is killed, all of the power in the carnival and surrounding neighborhood goes out, and a train passing nearby slows and stops. We did all of that in a 2D matte painting created by Belinda Allen, Robert Baird and Damien Thaller.”

The action returns to the mountains and a shattering of Logan’s happy life with the apparent death of Kayla at his half-brother’s hands. Filled with rage, Logan hunts down Creed, finding him at a local bar, the setting of a brutal fight between the two. “Creed is the stronger of the brothers,” said Pat McClung, “and so Logan gets the worst of this fight. He’s tossed all over the place — and that required a lot of wirework. Because it was too dangerous for the stunt people to wear bone claws in this fight scene, Soho tracked 3D claws onto Logan for all of those shots.”

Near the end of the fight, Creed releases a load of logs stacked on a train car, and Logan is buried in the timber. Though the set had been dressed with real and synthetic logs for the beginning and end of the scene, all of the rolling, tumbling logs were realized in 3D by Hydraulx. “We took a lot of photographs on the set,” said Erik Liles, “so we had reference of the various types of logs they were using. We also took photographs of the start and end positions of the logs, and then came back here and modeled the logs from scratch.” The impact on Logan was shot greenscreen, with a stunt actor. “It was originally planned to use a digital double for the crushing, but we were able to use the 2D greenscreen element just fine.” Hydraulx did build a Logan digital double for a subsequent shot of the character being hit by a truck. “We had a complete scan of Hugh Jackman in all of his outfits, as well as a scan of him nude, and we built our doubles from those scans.”

Having been promised a procedure that will make him considerably stronger than Creed, Logan travels with Stryker via helicopter to the government compound at Alkali Lake, the establishing



Inside the compound, Logan is lowered into a water tank and surrounded by rotating needle guns. On set, production had prop guns – sans needles – moving over Hugh Jackman in the tank. Rising Sun Pictures tracked CG needles to the spinning props in postproduction.



Due to a late redesign of the needle rig, RSP also replaced the prop guns in some shots, using 2D techniques. RSP added additional joints to the rig’s articulated arms to accommodate the convulsive movement of Jackman’s body in the scene, and animated digital bubbles to augment those in the practical water tank.

shot of which was a matte painting by Rising Sun. The CG shot included a sweeping mountain vista, the lake's edge, a concrete landing platform, a dam in the background, and a foreground element of a real metal door buried in a cliff side, shot on Cockatoo Island in Sydney. The art department also built sets for interiors of the compound, including the surgical theater where Logan is strapped into a water tank, surrounded by large rotating needles that will bore into his skeletal structures and infuse them with adamantium. "Rising Sun was in the water," said Pat McClung, "and we had prop devices rotating over him; but we couldn't have real needles on them because it was too dangerous. So Rising Sun tracked in the needles later."

"There was concern about it being too gruesome," elaborated Tom Proctor, "so you don't actually see the needles penetrating his skin or drilling into him. They show that on an x-ray screen, and then it cuts back to him in the tank, the needles firmly imbedded in his skin. We had quite a few closeups of the needles in his head, and so our matchmover/camera department lead, Justin Long, had to do a lot of complex tracking on Logan's face in the tank." In addition to adding the spinning needles, RSP replaced the prop needle guns in several shots to accommodate a redesign of the layout. "We did quite a bit of 2D work to take out the practical guns and rigs that were visible in the plates. We built the guns and the needles to match what they'd had on set; but because he was shaking his body around throughout the scene, the guns had to move around on their articulated arms a bit more than the practical rig would have allowed. So we embellished the joints to allow for extra movement. We also built in some additional hoses." Effects animator Sam Hancock animated water bubbles to augment those in the practical water tank.

Hearing Stryker order his elimination — now that he has proven the efficacy of the adamantium infusion procedure — Logan bursts from the tank, his lethal adamantium claws fully extended. In building practical models, A.I. created molds from claws used in previous X-Men films, then cast theirs in urethane so that they were rigid enough to simulate metal, yet breakable enough to avoid serious injury on set. "They were built on a little wire rig," said Alec Gillis, "and the wires extended down in between the fingers into a small plate that Hugh Jackman held in



When Logan escapes the compound, Stryker's agents give chase via ground vehicles and aircraft. During the pursuit, Logan — on a motorcycle — rakes his adamantium claws along the side of a Humvee, blowing out its tires and causing the vehicle to flip. Hydraulx assembled the shot, blending greenscreen footage of Rising Sun on a gimbal-mounted motorcycle with a background plate shot on location from a camera car. For the car flip, Hydraulx built a fully rigged digital Humvee from photographs, then intercut its CG vehicle with a practical Humvee that special effects supervisor Dan Oliver had blasted into the air via a large piston rig.



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his palm, curling his fingers over it to keep the claws rigid and flush to the skin.”

Rising Sun was among the vendors charged with tracking in 3D adamantium claws to shots in which the practical props were not used. “We were given the direction to make them look like the surface of an Apple laptop,” said Tom Proctor, “that brushed aluminum look. In all these shots, what really made the claws sit in the environment was the color reflection of the environment. In most cases, we got good reference in the form of gray and chrome balls. We also had the reference of the practical models that were actually there in the environment. Crew members would hold the claws in position and turn them around to give us an indication of how they would react in that lighting.” Rising Sun added 3D hoses that pop off of Logan’s back as he breaks free of the tank, and digitally closed a gunshot wound Logan suffers as he attempts to escape the compound.

Logan runs through corridors and finally makes his way to an exit — a large metal door imbedded in a cliff wall. In an exterior shot, the camera captures metal claws slashing an ‘X’ into the door, a foreshadowing of Logan’s membership in the X-Men. “Originally they were planning to shoot that practically,” noted Proctor, “but the design texture on the door changed significantly. Also, there were a lot of flashing lights on the practical door, and they decided they didn’t want those. So we had to do a major 2D paint-out in the shot where Logan is cutting through the door. We had to take flashing lights off of Hugh Jackman’s body as he steps through the door, which involved taking frames between the flashes and warping them into place on top of the frames where the flash of light was on.”

When the lights and door had been painted out, RSP tracked in its own digital door, with animated ‘X’ slashes. “We had to create a door rig that would, in effect, unzip between a completely clean door and this door with these very pronounced slashes,” RSP CG supervisor Dan Bethell explained. “Nick Pitt-Owen modeled a door with these slashes completely revealed, with very jagged edges. And then, in 3D, we rigged together a door that unzipped in time with the claw animation. That was rendered out as a series of passes, and composited together so that the inside of the slashes was a different material than the door surface. We also spent some time getting a naturalistic camera and framing. It starts in quite close on the door so you see the claws initially penetrate; and then, as Logan makes this slashing X, there’s a pullout.” Sam Hancock added animated sparks to shots of the claws ripping through the metal door.

special effects supervisor Dan Oliver had blasted into the air via a large piston rig. “We got the year-class experience in making our models,” Logan meets with the once muscular mutant Fred Dukes (Kevin Durand), now the flabby and enormous ‘Blob.’ A.I built a foam latex fat suit for Durand to wear as Blob, which featured multiple layers of padding, and hand-punched hair and lace pieces applied to the actor’s neck and chest. A full multiple-piece makeup plumped out his face.



Joining Logan in Vegas is mutant John Wraith (will.i.am), who is able to teleport from one location to another in a split second. Hydraulx realized the teleportation effect through a combination of 2D and 3D effects. For Wraith’s sudden disappearance, Hydraulx created a digital version of the character that quickly dissolved, revealing his skeleton, and then contracted to a pinpoint of energy. Hydraulx reversed the sequence in shots of Wraith arriving in a new location, transitioning from the pinpoint of energy to his skeletal form and finally to his fleshed-out body, tracked to the live actor’s position in the shot.

Production shot a helicopter plate in New Zealand for the shot of Logan exiting the door and running along the topside of a tall waterfall. In the next wide shot, created by Hydraulx, a digital Logan jumps off the waterfall and falls into the water below. The action then cuts to a farm, where an elderly farmer and his wife spot the naked Logan entering their barn, and soon befriend him. When Agent Zero and his government squad track him down there, they kill the couple and proceed to mount a ground and helicopter attack. “The chopper flies in and fires two missiles into the barn,” related Pat McClung, “which were Hydraulx CG missiles. Logan comes blasting out of the barn on a motorcycle, and this starts the Agent Zero chase, which included a lot of greenscreen with Hugh Jackman on a practical motorcycle. Overall, this sequence was shot very thinly and we had to patch it together with a lot of Hydraulx visual effects shots.”

During the chase, Logan, on the motorcycle, rides close to the side of a government Humvee, raking his claws across it and blowing out its tires, causing the vehicle to flip. “He pops the first tire,” explained Erik Liles, “and you see him start the slice down the side of the door — sparks are flying, smoke is coming out and little chunks of debris and twisted metal are being shaved off as he goes through to the back tire and pops that, causing the entire Humvee to flip. We had Logan shot on greenscreen, and there was a background plate shot from a camera car. But we had to build a fully rigged and animated Humvee off photographs of the one in the scene. They had done some practical stuff, too, using a big piston rig to blast the Humvee into the air, and we had to intercut our CG Humvee with that.”

When a missile explosion propels Logan into the air, he jumps onto the low-hovering helicopter and slices its rotor blades. Dan Oliver executed the helicopter’s subsequent crash, sliding a helicopter shell down a cable on location. Hydraulx added digital rotor blades in post.

Having learned that Stryker and Creed are kidnapping mutants and taking them to a secret lair for experimentation, Logan goes to Las Vegas in search of information about the site’s location. Hatch FX created a matte painting of the city, providing the backdrop for a production plate of Logan on the motorcycle. In Vegas, Wraith leads Logan to the once muscular Fred Dukes, now flabby and grown to enormous size. A.I built a fat suit for



Hydraulx also created shots for a New Orleans casino scene in which Gambit (Taylor Kitsch) displays his mutant powers, using telekinesis to perform extraordinary card tricks. Hydraulx animated CG cards for the scene.



Kevin Durand to transform him into 'Blob.' "Blob was a big two-stage makeup," said Tom Woodruff. "The fat suit was a full-body sculpture — by Davis Fandino and Steve Koch — to show large sections of belly and arms that were exposed. It was a foam latex suit filled with multiple layers of padding and weighted sections. Justin Ditter and the A.I hair department punched hair and applied lace pieces that laid on the back of the neck and chest. And then he had a full multiple-piece makeup to plump out his face." The paint scheme was done by Mike Larrabee and the makeup was applied on set by Randy Westgate, Colin Ware and Alec Gillis. For shots in which Logan spars with Blob in a boxing ring, Hydraulx replaced the torso area of the fat suit with a 3D Blob, using simulations to create realistic ripples of flesh.

In consort with Stryker, Creed attempts to kidnap high school student Scott Summers (Tim Pocock) – also known as Cyclops – chasing him through school corridors. Luma Pictures simulated the searing laser beams emitted from Summers' eyes, using Maya fluids and a particle system to create multiple 3D elements. Luma added dynamic elements such as hot embers, flames and debris in shots of the beams hitting surfaces, and also built a digital approximation of Summers' face to facilitate interactive CG lighting.

The action cuts to a high school where Creed captures a young Scott Summers (Tim Pocock), known also as Cyclops. Luma Pictures generated a digital double Creed for shots of the character chasing Summers through school corridors. "They needed a digital Creed because of his acrobatic movements," said Luma visual effects supervisor Vince Cirelli. "Creed jumps up onto the sides of the walls and does all kinds of things that would be very difficult to film with a guy on wires — although they did shoot him running down the hall, as reference. Using that reference and scans of the actor, we modeled a 3D Creed. We then started working on the rigging and the skeletal system, and blocked out animation to show the director. In parallel, we were also developing skin shaders and cloth simulations for the long overcoat he wears. Digital Creed is full-frame in some shots, so it was very important for us to match the surface properties of a human being. We started with photography, but there was a lot of additional painting required because the lighting was already baked into the reference stills of the actor. We needed to replicate the environment lighting so that Creed would integrate with all of the appropriate lighting qualities you would expect with a real person moving through the scene."



After Logan bests Creed in an alley fight, Gambit agrees to fly him to Stryker's secret lair, located at the abandoned Three Mile Island nuclear plant. Soho VFX realized the establishing aerial view of the island, creating a wide, all-CG shot that emerges from the clouds to reveal illuminated Three Mile Island structures below, surrounded by water and distant landscapes. Though production had gathered reference photographs of the real location, the film's exteriors depicted a slightly stylized version of the Three Mile Island site.

Because Luma's digital Creed would be interacting with the school corridor, the team also built set geometry. "We projected the plate imagery onto low-resolution geometry," said Cirelli. "We created lockers lining the high school hallway and built out the walls so that we'd get the proper shadows and reflections — where there was glass in the scene, we needed to see Creed reflected in that. It was always a blend between the plate photography and the CG build."

Summers' protective glasses are knocked off his face in the course of the chase, unleashing the powerful laser beams that fire from his unprotected eyes. "That required us to build a rough

approximation of his face so that we could get the CG lighting to react on it,” said Cirelli. “The beam itself was a composite of multiple 3D elements created using Maya fluids and a particle system. We also created dynamic elements such as hot embers, flames and debris that are emitted where the beam strikes a surface.” For an aerial view of the school’s destruction via laser beam, Luma modeled a portion of the building’s exterior to create interactive lighting from the beam onto the roof and walls. “As the beam rips through the walls and trees outside, it triggers dynamic particle events that add to the chaos.”

From Blob, Logan learns that mutant Remy LeBeau (Taylor Kitsch), known as Gambit, knows the whereabouts of Stryker’s secret compound. Logan and Wraith find Gambit in a New Orleans casino, using telekinetic powers to perform a series of extraordinary card tricks. Hydraulx animated CG cards for the scene. “Our challenge was to come up with some cool card tricks,” stated Erik Liles. “We went through a lot of iterations, coming up with different types of tricks. We went from natural things that you’d see a seasoned poker player do, flipping cards in one hand and spreading them out, all the way to some really fantastical things to show that Gambit can manipulate these cards without even touching them.”

Creed arrives on the scene and, after killing Wraith, engages Logan in a fight in an alley, soon joined by Gambit. The fight was a combination of live-action and visual effects. Soho VFX built a synthetic New Orleans environment for a shot of Gambit running along a rooftop, and then jumping into the alley to join the fray. “That was one of our most challenging shots,” said Soho visual effects supervisor Allan Magled. “All they shot on the greenscreen stage was a piece of the roof and Gambit running on it. We had to extend the roof and build literally everything around it — downtown New Orleans, a church, a bridge and even a riverboat in the water — in CG. Due to the extreme camera move and zoom, we couldn’t get away with a traditional matte painting background. So we built 3D buildings for anything that came close to camera or required a lot of detail; and as we got further from the camera we switched to 2D and eventually a matte painting. We went down to New Orleans and did some photo-surveys



Stryker releases his ultimate mutant weapon – the surgically and genetically enhanced Wade Wilson (Ryan Reynolds), now known as Deadpool. A.I took a head cast of Reynolds to create the Deadpool makeup, applied to the actor on set by prosthetics supervisor Colin Ware and his team.



Production filmed an extended fight scene between Deadpool, Logan and Creed – atop one of the Three Mile Island cooling towers – on a minimal greenscreen set. Hydraulx completed the fight shots, compositing in matte-painted skies and all-CG environments that included cooling tower structures and pieces of set dressing built in Maya.

and lidar scanning so that we would have the right scale and angles of things; but then we mixed it around to get the best of New Orleans in this one big crane shot.”

Gambit slams his walking stick into the alley, translating his energy force into the ground and causing it to ripple and then explode. “We built a 3D alley floor for those shots,” said Erik Liles, “so the cobblestones could dislodge and ripple as the energy disperses. We built CG objects the energy force interacts with, too — so you’d see a garbage can sliding and trees moving. A lot of it was simple 2D effects, using basic light and distortion effects to create the shockwaves.” Creed — now no match for his adamantium-enhanced half-brother — escapes, but Logan stops Gambit as he attempts a getaway up a fire escape ladder, slicing the metal rungs with his claws. Soho VFX created a 3D fire escape for the shots, and added CG debris and sparks raining down.

Gambit agrees to fly Logan to Stryker’s compound, located at the abandoned Three Mile Island nuclear facility. Soho VFX realized the establishing aerial view of the island. “We start with a wide all-CG shot coming out of the clouds,” related Allan Magled, “revealing Three Mile Island below. The island is CG, the water all around it is CG, and the airplane is CG. We then fly lower, and Logan jumps out of the plane, into the water. We built a Logan digital double for that shot, as well as a view of the island that is closer to camera.”

Inside the decommissioned nuclear plant, Logan finds Kayla alive, but under the control of Stryker, who has imprisoned her sister — a mutant who can form a hard diamond shell around her body at will.

Hydraulx created the *Diamond Girl* effect, building a digital model from scans, applying a displacement-based diamond texture to that model, and tracking it to the live-action performer. Kayla and Logan release the girl, and all of the mutants being held in cages in the bowels of the compound. Intermixed with live mutant performers were characters digitally enhanced by Luma Pictures. “There’s a toad-like creature with a long, darting tongue in one of the cages,” said Vince Cirelli. “For that, we created a completely digital face and tracked it to an actor’s body. In that same scene, you also see Frost, frozen in the cage that she’s in. For the Frost shots, we did a 3D extension on the cage and a color correction on the actress to make her skin look desaturated. We also took out her pupils and irises to create white eyes.”

Luma also created shots of the gaseous Vapor mutant using multiple dynamics simulations, layered and composited over one another. “Our final character was Cannonball,” said Cirelli, “who is able to move at extreme velocity. He is strung up in these rubber-band-type straps in the center of the cage, and he moves very rapidly, bouncing side to side. We created a digital double for that, and then animated him at sub-frame intervals to create the unique motion effect. Then, when he slows down and looks at the camera, we blended back into the plate they had shot with an actor in the cage.”



The fight ends with Logan decapitating Deadpool, causing his laser-beam eyes to wildly discharge as his head and body plummet into the tower. Hydraulx built a 3D cooling tower for shots of the beam slicing through the structure, and employed rigid body simulations for subsequent shots of the tower collapsing. Hydraulx added pyroclastic smoke and debris – created with Maya fluid simulations and rendered in mental ray – to complete the shots.

Stryker releases his ultimate weapon — the surgically and genetically altered Wade Wilson, now known as Deadpool, who has been infused with the DNA of many different mutants. “Deadpool has Logan’s adamantium skeleton and healing powers,” noted Pat McClung, “Wraith’s teleporting abilities, and Scott Summers’ lasers, but with a surgically made visor, so he doesn’t have to wear one.”

A.I contributed to a scene revealing the character as his transformation into Deadpool is in progress. “We created an animatronic head of the character with eyes articulated by mechanical designer Dave Penikas,” explained Tom Woodruff. “It was something you could never do with a makeup on an actor because there was all this negative space around the eyes. It was all radio controlled, with RC servos and motors to control the eye movement and make it look alive.” A head cast of Ryan Reynolds, used to build the animatronic, was also employed to devise the Deadpool makeup, applied to the actor on set by prosthetics supervisor Colin Ware and his team.

Creed, Logan and Deadpool fight atop one of the compound’s cooling towers, a sequence handled by Hydraulx. “The whole fight scene was shot on greenscreen,” noted Pat McClung. “The only thing that was real in the scene, beside the actors, was the floor they were standing on. Hydraulx extended that with a digital set and matte painting of Three Mile Island, with all the cooling towers and support facilities. Basically, they built the entire island — every grain of sand and dirt and every tree, building and vehicle — in Maya.”

The fight ends with Logan decapitating Deadpool, and the character’s uncontrolled beam-emitting eyes cutting through a cooling tower, causing it to collapse. Hydraulx built the tower in CG and then collapsed it through the use of rigid body simulations, adding pyroclastic smoke and debris. “On top of the simulations,” stated Erik Liles, “we animated hero pieces into the scene, as well as doing fluid sims for the dust and debris to enhance the collapse.”

Luma Pictures generated shots of the Three Mile Island compound after the destruction, integrating greenscreen elements of Creed and Logan into the environment. “We did roughly 100 shots for the aftermath,” stated Vince Cirelli. “We created a destroyed cooling tower in 3D, and painted on top of that to create multiple backgrounds. Some of the challenges were trying to integrate the foreground, which had been shot in a studio lighting scenario. In compositing, digital supervisor Justin Johnson did a lot of grading tests to better integrate the characters into the 3D sets. We also treated the foreground plate to react to the additional fire elements we populated into the environment, so there would be a flicker on the faces of the actors.”



Logan emerges the victor in the fight, but awakes amidst Three Mile Island wreckage with the memory of his past life erased. Luma Pictures created approximately 100 aftermath shots of the post-destruction Three Mile Island compound. Among Luma’s 3D elements were pieces of cooling tower structures, extended with matte-painted backgrounds and integrated with foreground actors and set pieces photographed on stage. Luma populated the environments with practical fire elements, and added interactive flicker lighting onto the faces of the actors in the scene.

The film ends with the freed mutants joining Professor Xavier (Patrick Stewart) aboard a black helicopter — a 3D asset created by Frantic Films — and Logan awakening with the memory of his previous life erased. In a shot executed by Matte World Digital, the camera pulls back from Logan and Kayla, revealing all of the Three Mile Island aftermath. “It was a huge ‘powers of ten’ shot,” explained MWD supervisor Craig Barron. “Pat McClung sent us a plate looking straight down at Hugh Jackman and Lynn Collins on a little piece of sand and gravel, with the camera rising up about 30 feet. We then continued the move up to reveal all the wreckage, then back even further to include the whole island and finally into the clouds. Digital matte artist Eric Hamel created five 3D matte paintings, the biggest of which was 16K. They were composited together by Geeta Basantani, reducing in frame one after the other, looking as if they were one continuous shot. That 16K resolution was unwieldy to work with, but necessary because we wanted to keep accelerating and pulling back without the shot ever looking blurry or soft.” To texture the Three Mile Island structures, Barron flew over the decommissioned Rancho Seco nuclear power plant in Sacramento and took digital photographs. “3D artists Luis Hernandez and Morgan Trotter used my photos with photo-mapping techniques to create the buildings. And then, Eric Hamel added all the destruction to finish the shot. It was enormously helpful to start with the real thing.”

Due to a delayed production schedule up front, *X-Men Origins: Wolverine* presented more than the usual number of postproduction challenges. Not only did its effects artists have to produce images that would live up to those featured in the previous *X-Men* films and meet the expectations of the many *X-Men* comic book fans, they had to do so within extraordinarily tight time constraints. “I’ve been doing this for a very long time,” Pat McClung commented, “but I don’t think I’ve ever been on a film that was as down-to-the-wire as this one. We wound up with 17 vendors on this show, and every one of them should be commended for delivering some really tough shots, really quickly. It was a great team effort.”

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Matte World Digital executed a ‘powers of ten’ shot that ends the film. Starting with a plate that looked down on Hugh Jackman and pulled up approximately 30 feet, MWD continued the move all the way up into the clouds, transitioning between five 3D matte paintings that revealed all of Three Mile Island and its environs. In the final composite, the matte paintings were reduced in frame, one after the other, to create the illusion of a single continuous shot. MWD used photo-mapping techniques to texture Three Mile Island structures with digital stills of the decommissioned Rancho Seco nuclear power plant in Sacramento.

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